ENGINEERING AND

BOILER HOUSE REVIEW

ESTABLISHED 1899

TWO SHILLINGS & SIXPENCE

VOL. 73 NO. 8 • THE PIONEER STEAM JOURNAL • AUGUST, 1958

350°F

300°F

250°F

For even temperatures use DEWRANCE-YARWAY

STAINLESS STEEL IMPULSE STEAM TRAPS

- Suitable for all pressures up to 400 lb/in² 842°F without change of valve or seat.
- Small size, light weight.
- Easy to install, easy to maintain.
- Stainless Steel.
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- Internal parts can be renewed without removal of Trap from line.

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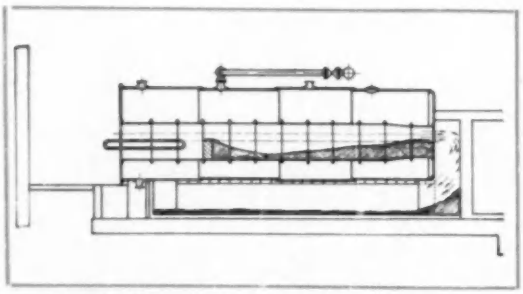
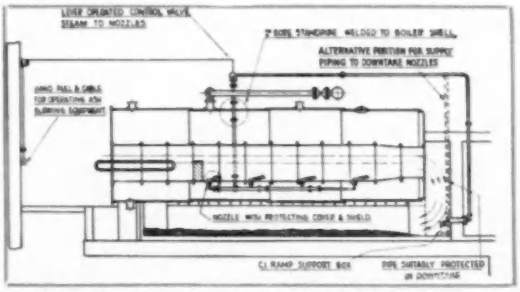
TO IGNORE MODERN BOILER FLUE CLEANING METHODS



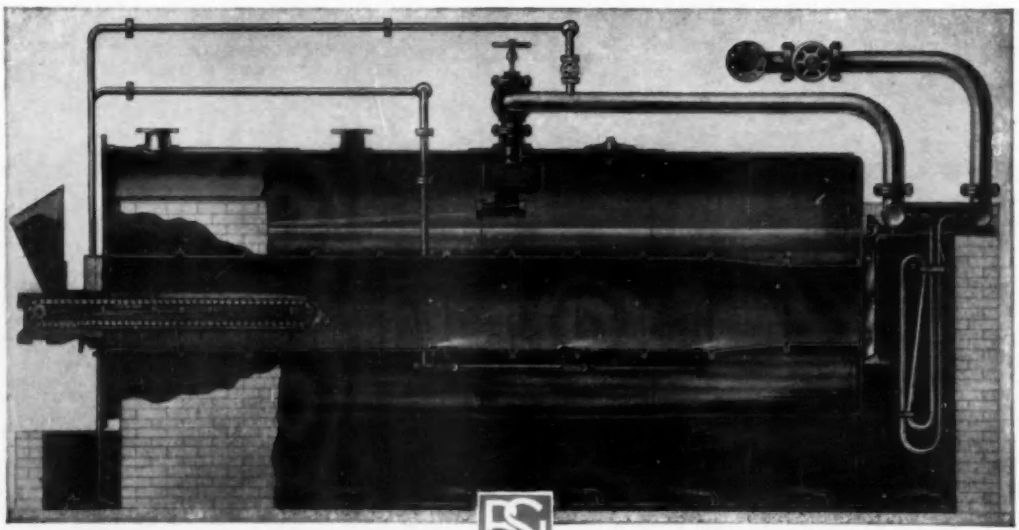
STOP THIS WASTE AND INEFFICIENCY—

ash deposit in the furnace tubes is the cause.


LEVER OPERATED CONTROL VALVE STEAM TO NOZZLES
2" BORE STANDPIPE WELDED TO BOILER SHELL
ALTERNATIVE POSITION FOR SUPPLY PIPING TO DOWNTAKE NOZZLES
HAND RAIL & CABLE FOR OPERATING ASH BLOWING EQUIPMENT
NOZZLE WITH PROTECTING COVER & SHIELD
CI RAMP SUPPORT BOX
PIPE SUITABLY PROTECTED IN DOWNTAKE

WITH 'BOLTON-GRAY' ASH BLOWING EQUIPMENT
(MODEL A)

ash is blown clear at will, maintaining the full designed heating surfaces.



MODEL B maintains the same conditions in the furnace tubes as Model A but with additional application to the flame bed, side flues, economiser chamber and final removal of ash to settling chamber. Boilers fitted with Model B can remain in service for periods up to twelve months without shutdown. Please write for brochure.

For clean air and reduced costs fit

"BOLTON-GRAY" PATENT ASH BLOWING EQUIPMENT

Bolton's
OF STOCKPORT

BOLTON'S SUPERHEATER & PIPE WORKS LTD. STOCKPORT

dm BS165

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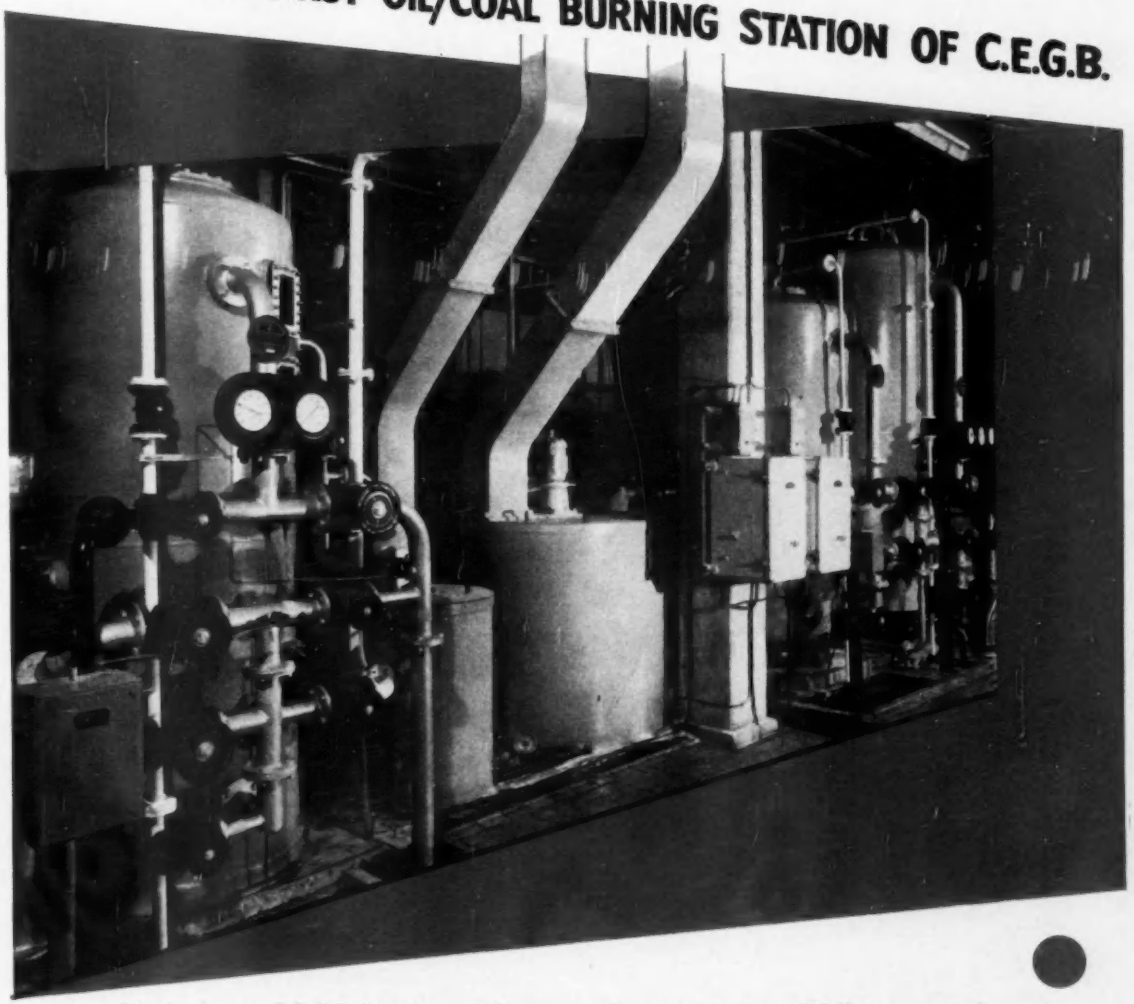
FOR FIRST OIL/COAL BURNING STATION OF C.E.G.B.



The boilers at C.E.G.B. Marchwood Generating Station operate at 925 lb. per sq. inch, and are provided with "Deminrolit" treated make up feed.

There is no split responsibility with a "Deminrolit" Plant because The Permutit Company design and manufacture the Plant, also develop and manufacture their own Ion Exchange Resins. This is exclusive to Permutit.

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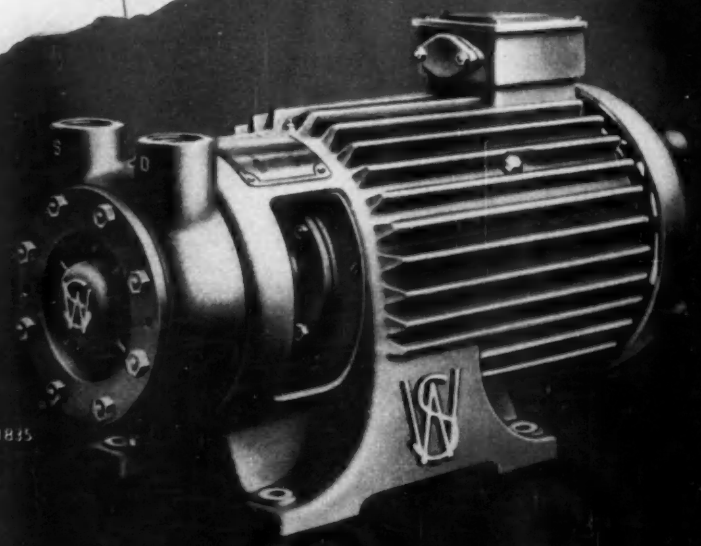

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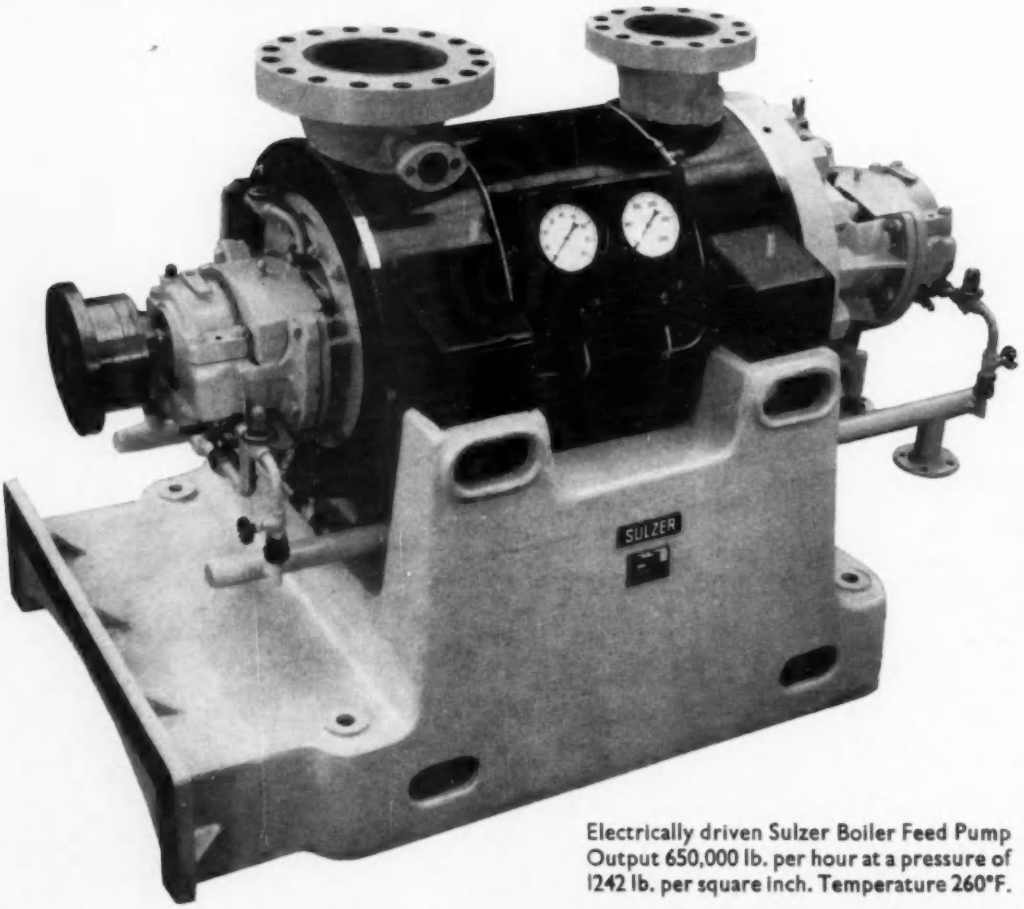

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1242 lb. per square inch. Temperature 260°F.

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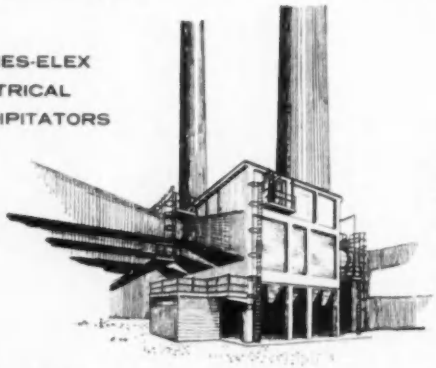

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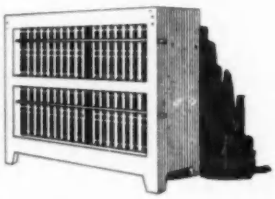

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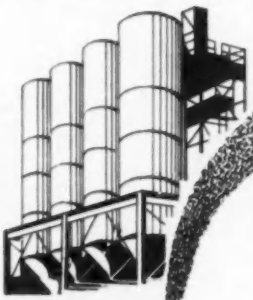

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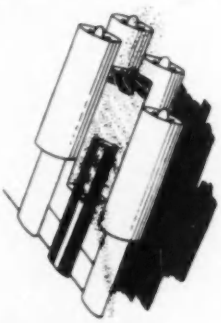

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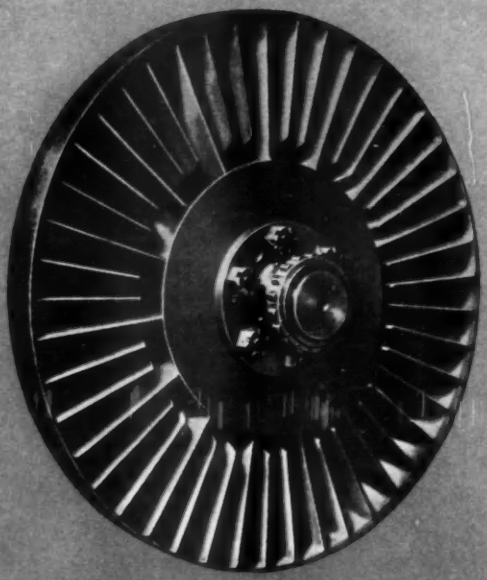

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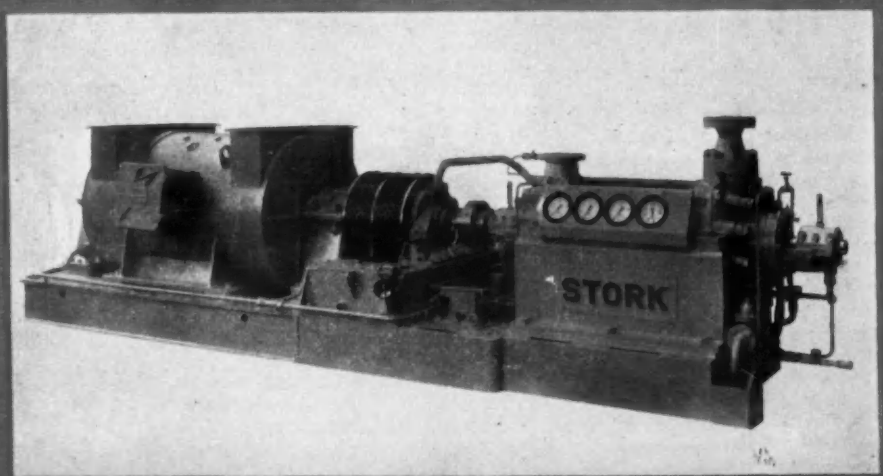

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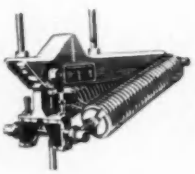

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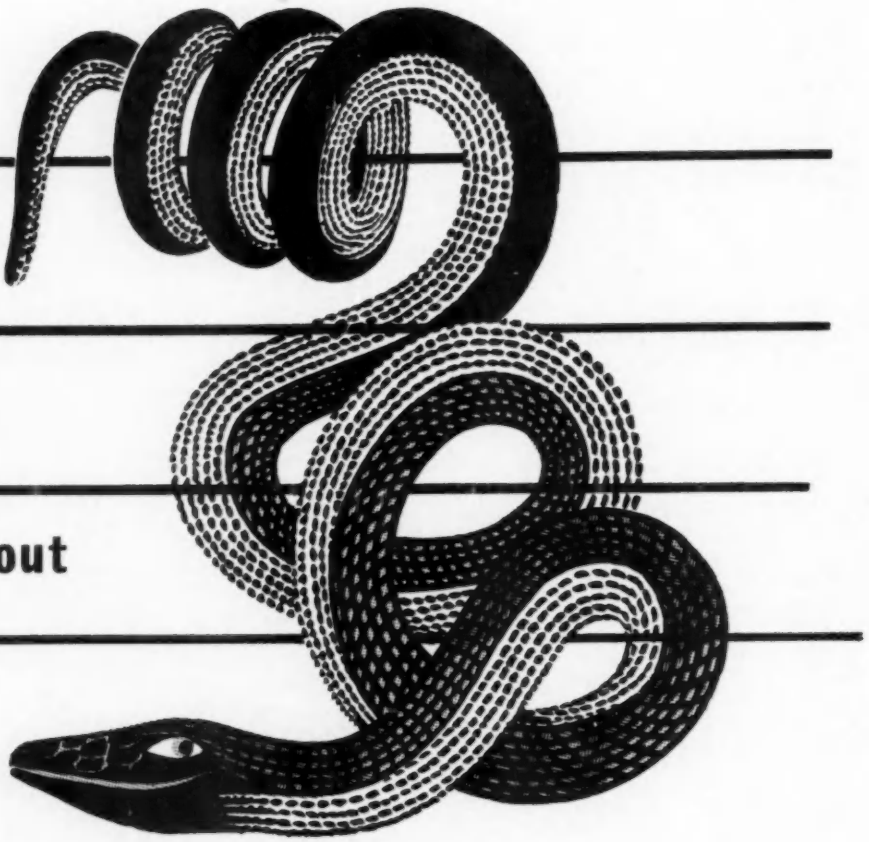

He would wriggle out of it

Someone must take the blame though—after all, corrosion in the boilers indicates an expensive blunder on somebody's part.

How easy to have specified "Apexior" at the beginning. "Apexior Number 1" positively prevents corrosion in boilers and steam-raising plant, where wet temperatures between 175° and 1000°F. are encountered. Absolute protection is assured with a yearly double coating, mechanically or brush applied. This also enables easier descaling as scale does not accumulate so much nor adhere so firmly to Apexiorised surfaces. For over 50 years, leading manufacturers of boilers and all steam-raising plant have relied on "Apexior" to fight their corrosion battles—why not follow their example?

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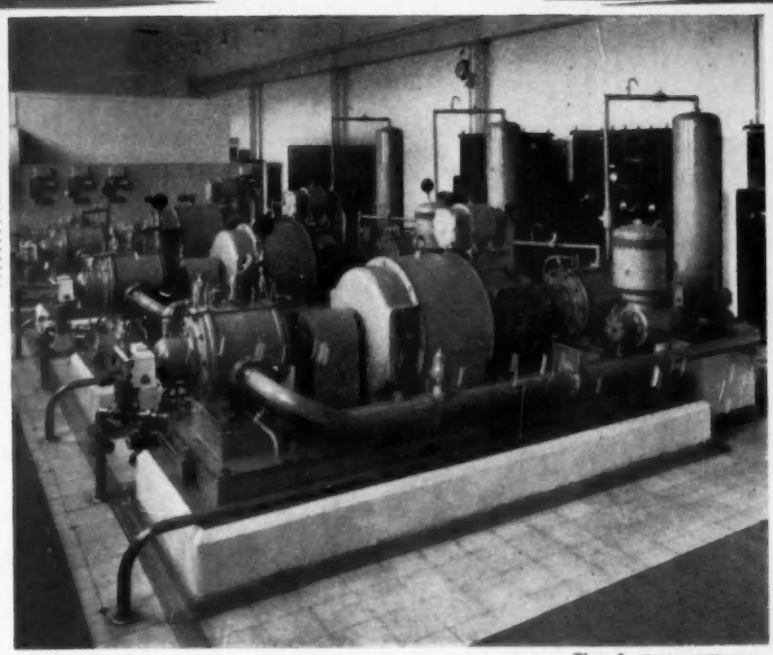

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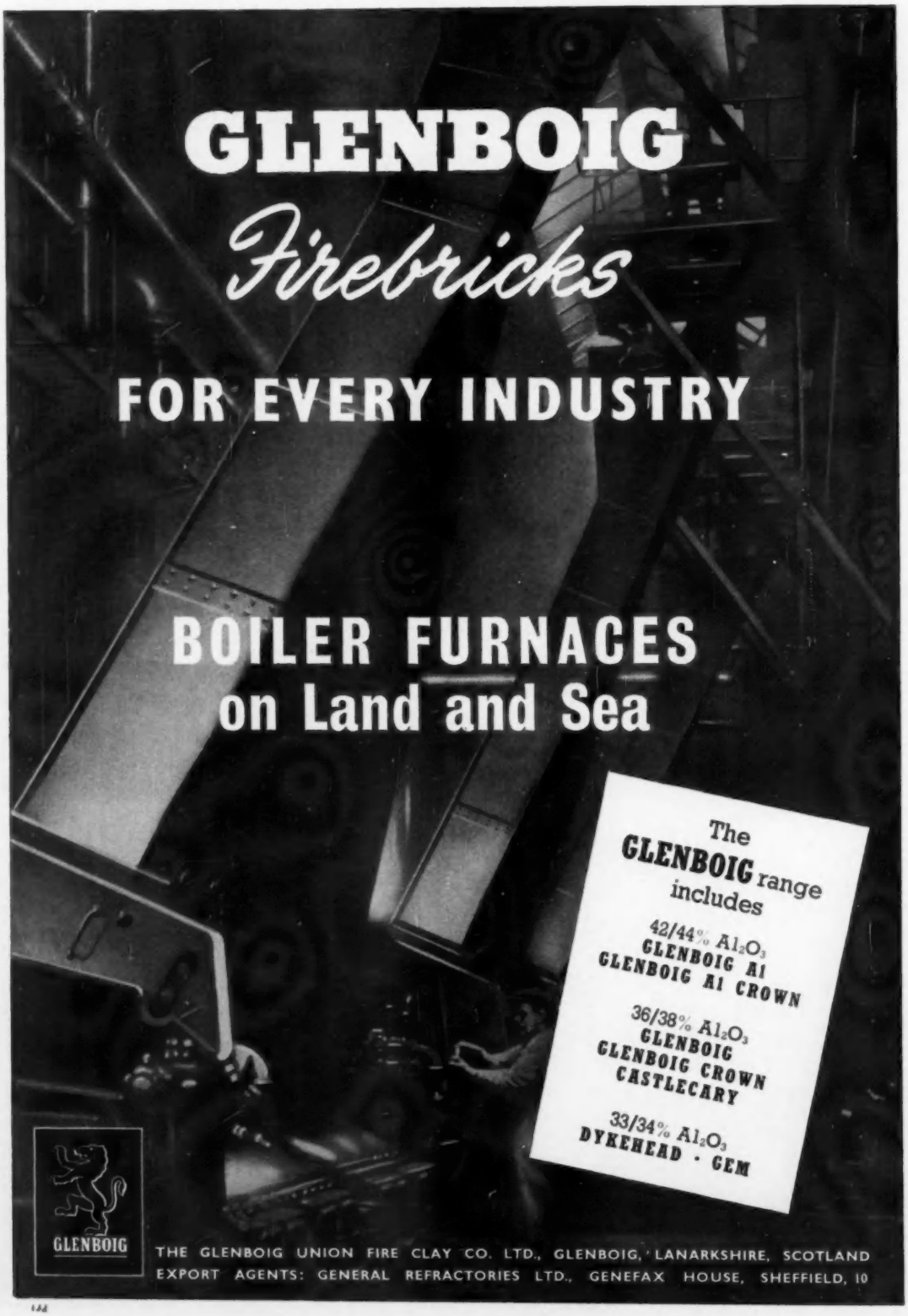
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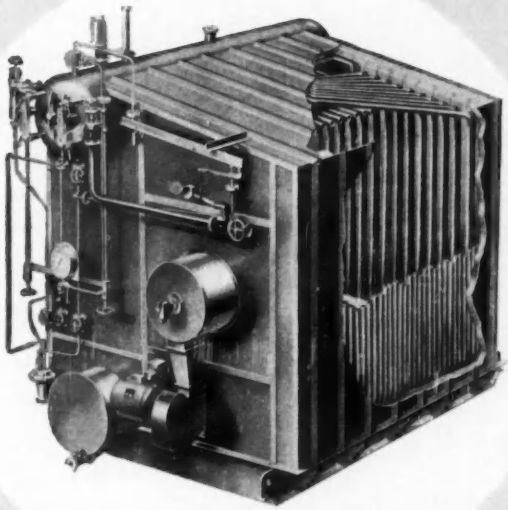

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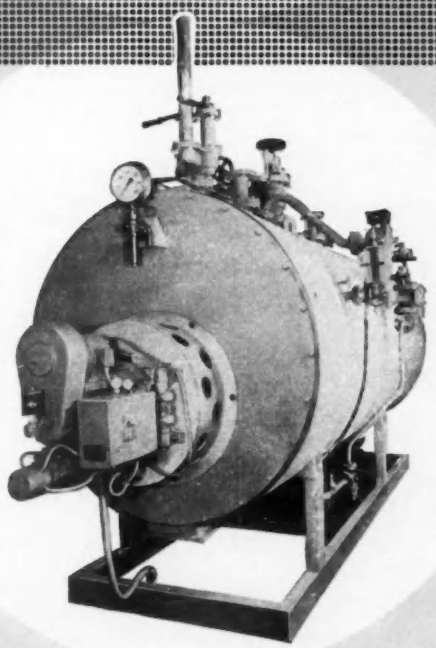

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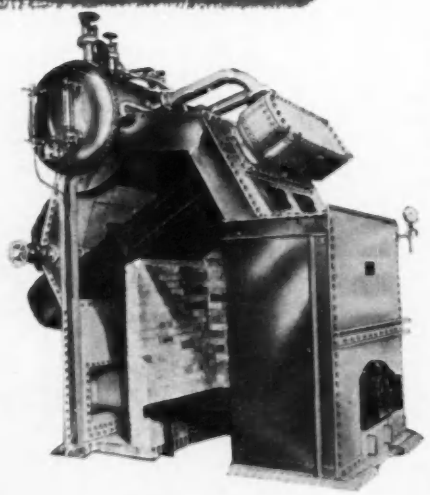

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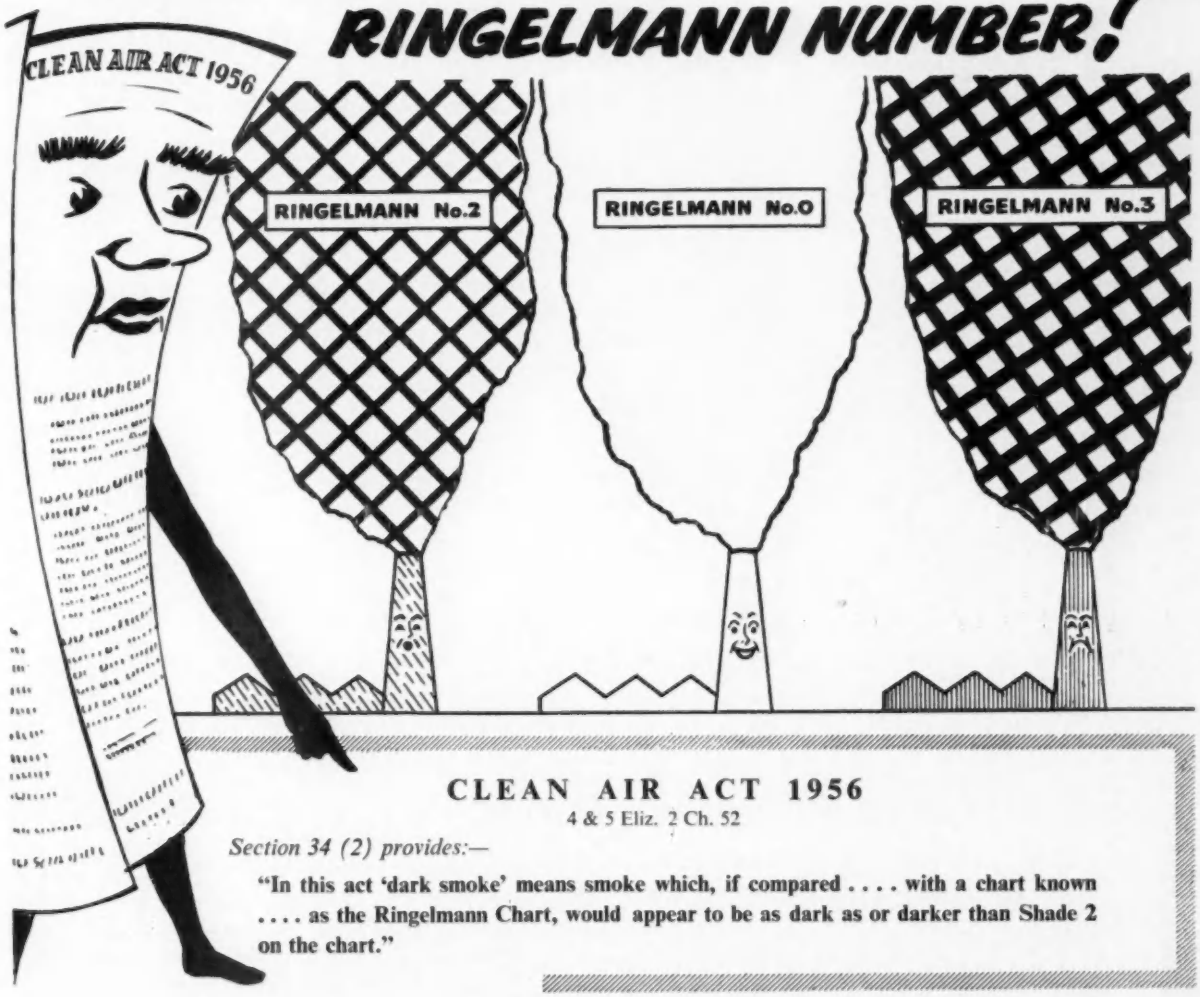

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For further information please write to: MORGAN REFRACTORIES LTD. NESTON, WIRRAL, CHESHIRE. TEL: NESTON 1406

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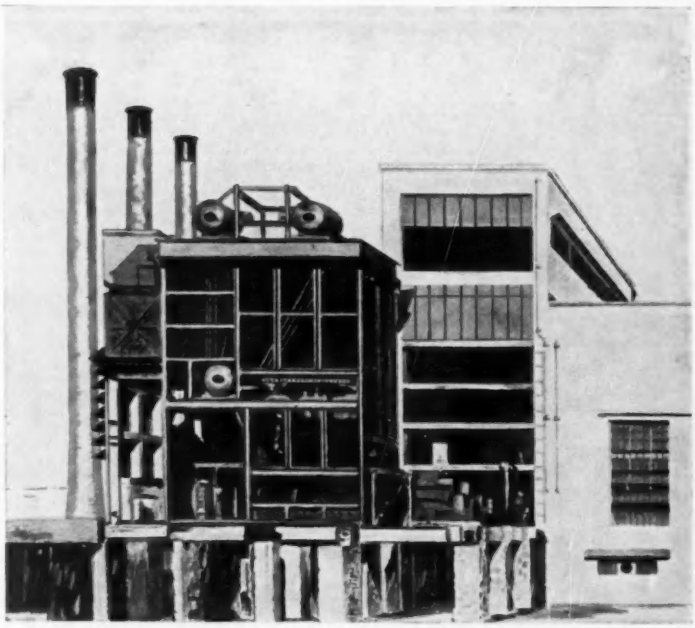


Power for India's expanding industry

CLARKE, CHAPMAN & CO. LTD. are installing two tri-drum boiler units in the new factory extensions of Messrs. Gwalior Rayon Silk Manufacturing (Wvg) Ltd., at Birlagram, Nagda, M.P. Two identical units are also being installed in the Birla Jute Manufacturing Company's cement factory at Satna. These installations incorporate chain grate stokers for coal-firing, water-cooled front and side furnace walls, suspended arches, superheaters, economisers, mechanical draught plant and grit collectors.

Evaporation: 50,000 lbs. per hour. Steam pressure: 400 lbs. per sq. in. Steam Temperature: 770° F.

CLARKE, CHAPMAN & COMPANY LIMITED
Victoria Works · Gateshead, 8
Co. Durham.

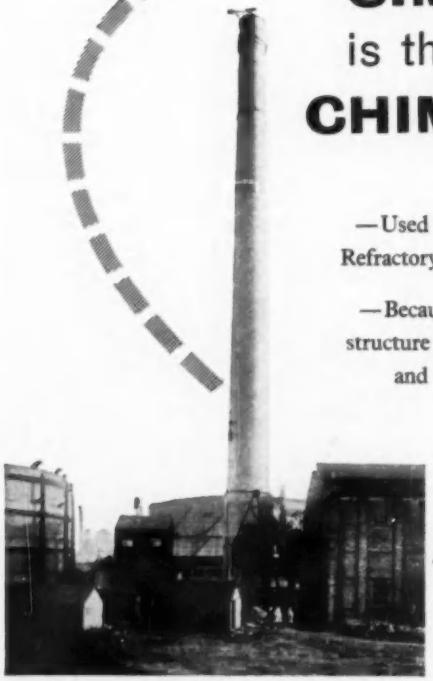
Clarke Chapman

LONDON Dunster House, Mark Lane, E.C.3.
GLASGOW 116, Hope Street, Glasgow C.2.
MANCHESTER 8, King Street, Manchester 2.

CIMENT FONDU
is the Ideal Cement for
CHIMNEY LININGS

—Used according to temperature conditions with Refractory, Insulating or Non-Refractory aggregates.

—Because it protects the steel, brick or concrete structure against attack by heat and by the acidity and sulphates from the combustion gases.



Wallasey Power Station. Ciment Fondu mortar was used for the jointing of the interior brickwork of this chimney.

Shell's Shellhaven Refinery, Essex. These 9 ft. diameter steel stacks have been lined with Ciment Fondu insulating concrete.

Battersea Power Station where chimneys have been lined with Ciment Fondu mortar.

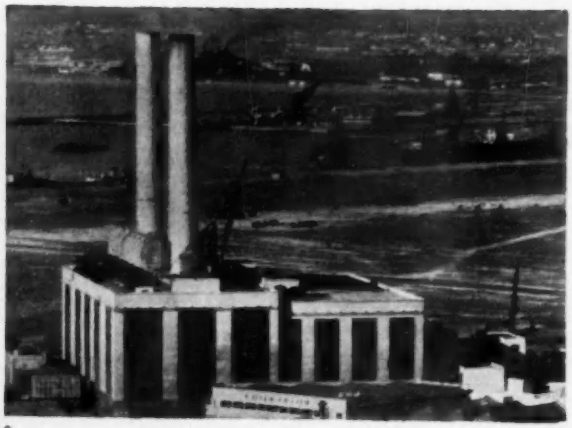


Table Bay Power Station, South Africa. Chimneys gunited with Ciment Fondu mortar.

REFRACTORY CONCRETE

The adaptable Refractory material made with crushed firebrick and CIMENT FONDU

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Regd. Trade Mark
ALUMINOUS CEMENT

The Cement for Industry

FOR SPEED · STRENGTH

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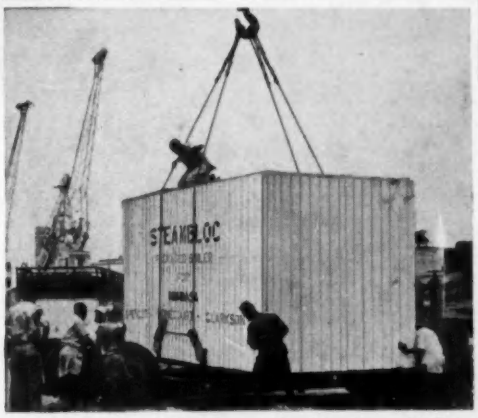
You are invited to write for further details and photographic examples

AP 3/1083

READY FOR SERVICE—EVERYWHERE
AT HOME OR OVERSEAS

A Steambloc, Model 700, rated at 18,000 lb. steam per hr. goes on board at Glasgow. It can be in service within 24 hours of arrival on site, at Home or Abroad.



Off loading at Mombasa for an Oil Refinery.

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Fully automatic packaged boiler

Laundry in Trinidad, Cannery in Kent, Dairy in New Zealand, Breweries on Thames and Tyne, distance makes no difference. The 'STEAMBLOC' is engineered, works tested and delivered as a single, compact unit, complete with all ancillary equipment, READY FOR IMMEDIATE SERVICE in every industry requiring steam or hot water for power, processing or heating.

Range, 1,500/18,000 lb./steam/hr.

Send for Publication No. 1628/3—The Steambloc Packaged Boiler

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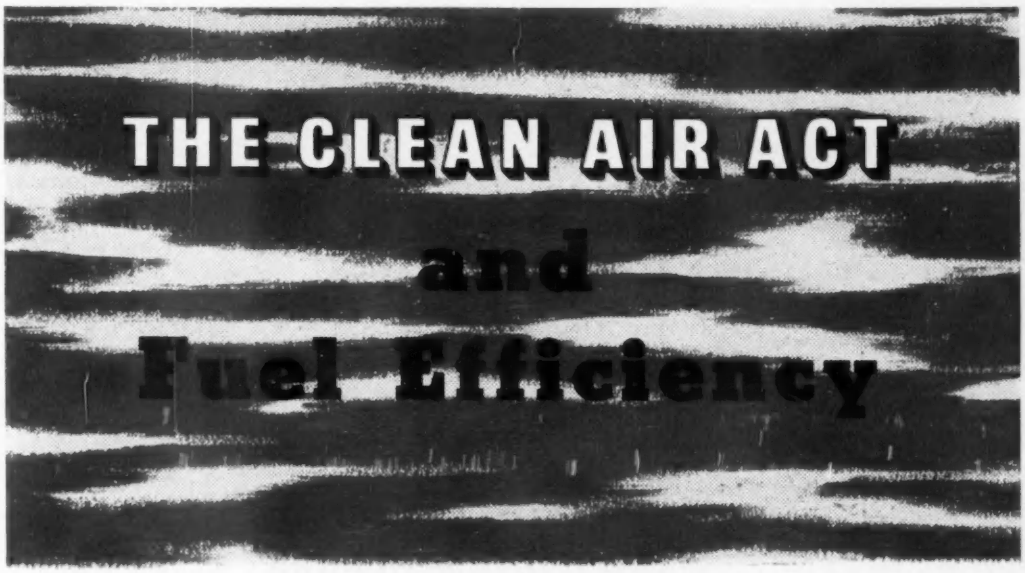

Have you taken ACTion yet? We offer priority to firms wishing to **abolish smoke emission** by the installation of mechanical stokers:-

UNDERFEED • CHAIN GRATE "LOW RAM"

Application can be made for a government loan to purchase or we can supply on rental. Most mechanical stoker installations will pay for themselves in coal saving alone within the first one to two years.

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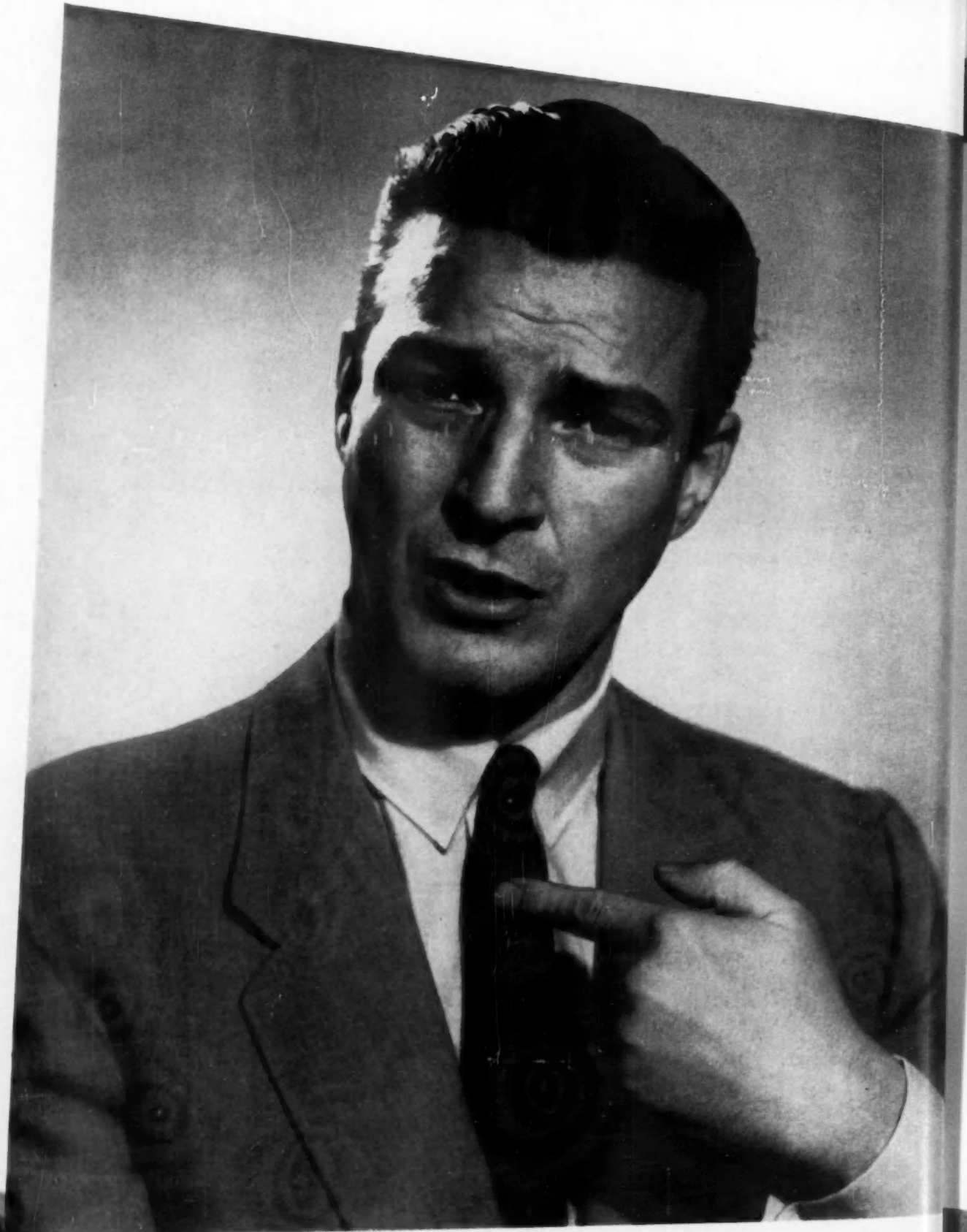
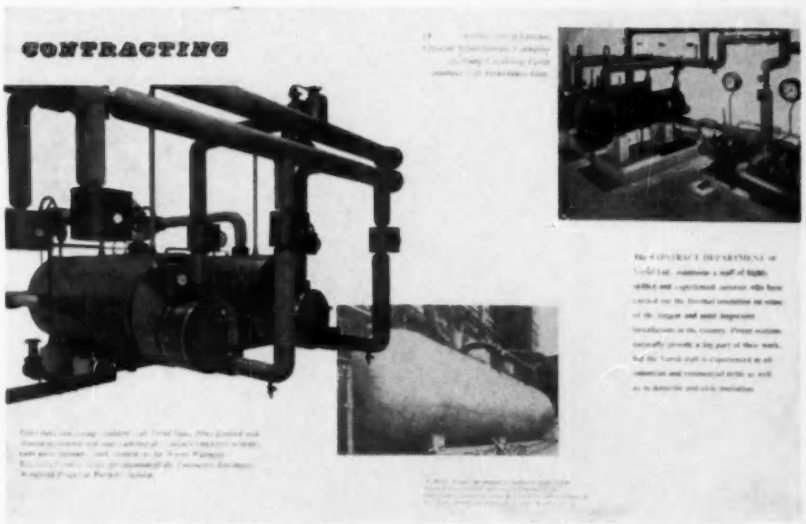
Salford 6, Lancs. Tel: Pendleton 1491

Brettenham House, Lancaster Place, Strand,
London, W.C.2. Tel: Covent Garden 2188



"As if I can help it!"

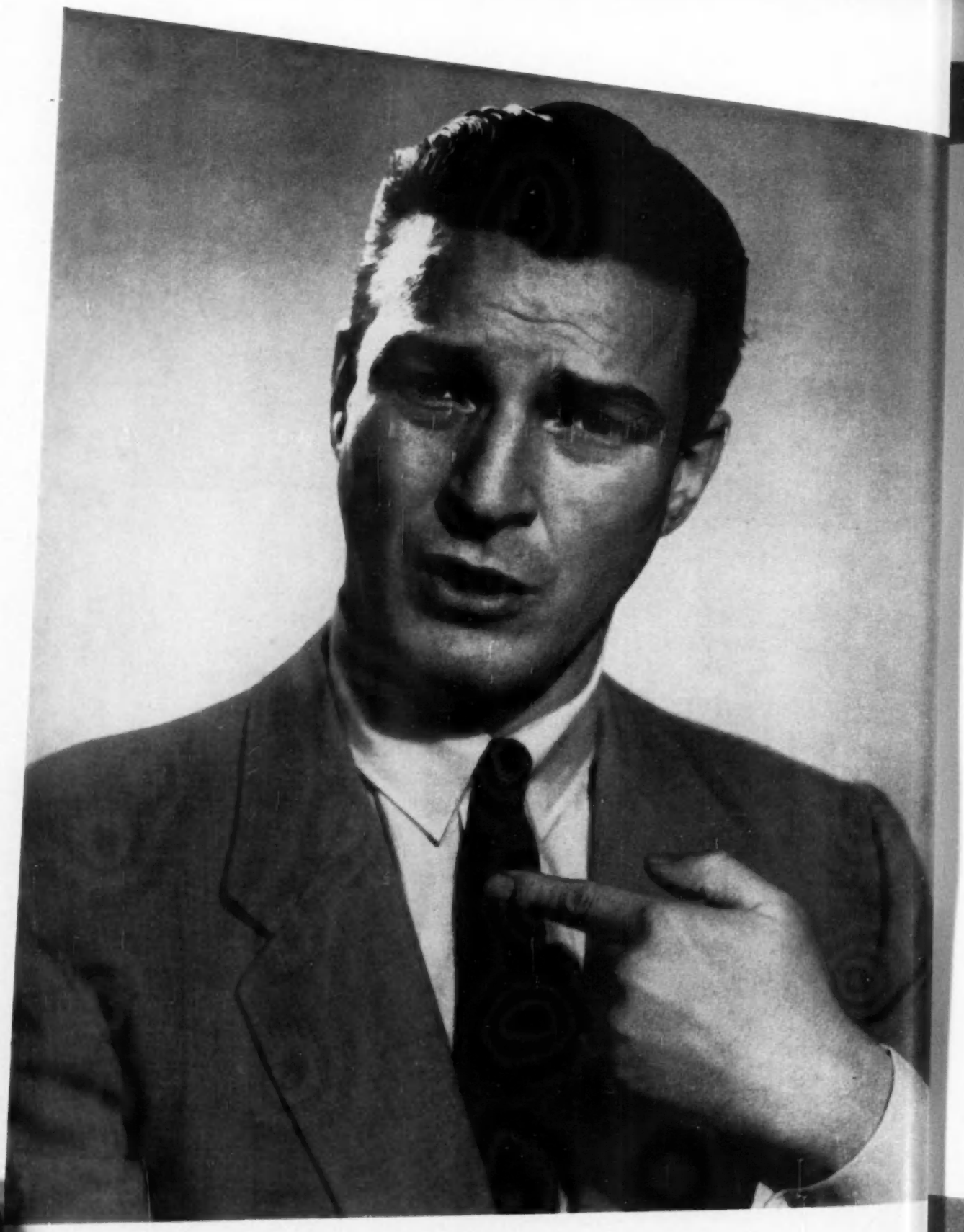
" Criticism, criticism, criticism. Can I help it if the cost of fuel keeps going up? So does my blood pressure. Every man-jack in the works is saving fuel till he bursts. I've brought in new routines, tried every conceivable thing. And all I get is: ' Can't we save more fuel? ' Well, we can't . . . it just can't be done, see? "



Reproduced from a new Versil publication "THERMAL INSULATION"

But can't it, Sir? Forgive us, but have you tried plugging concealed heat losses with better insulation? Have you, in fact, tried VERSIL GLASS FIBRE? We think you'll find it makes quite a difference, and you might even get bouquets instead of brickbats. So don't quit—just write to VERSIL Ltd., Liversedge, Yorkshire.

What You Need Is *Versil* **THE GLASS FIBRE INSULATION**



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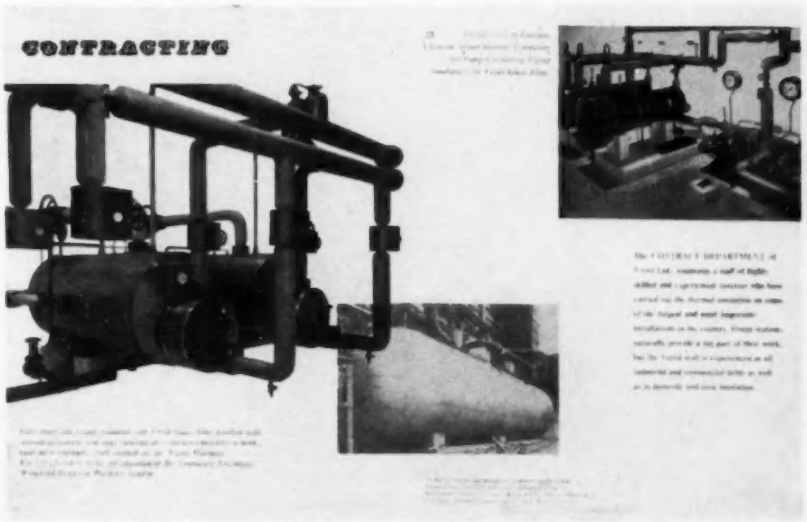

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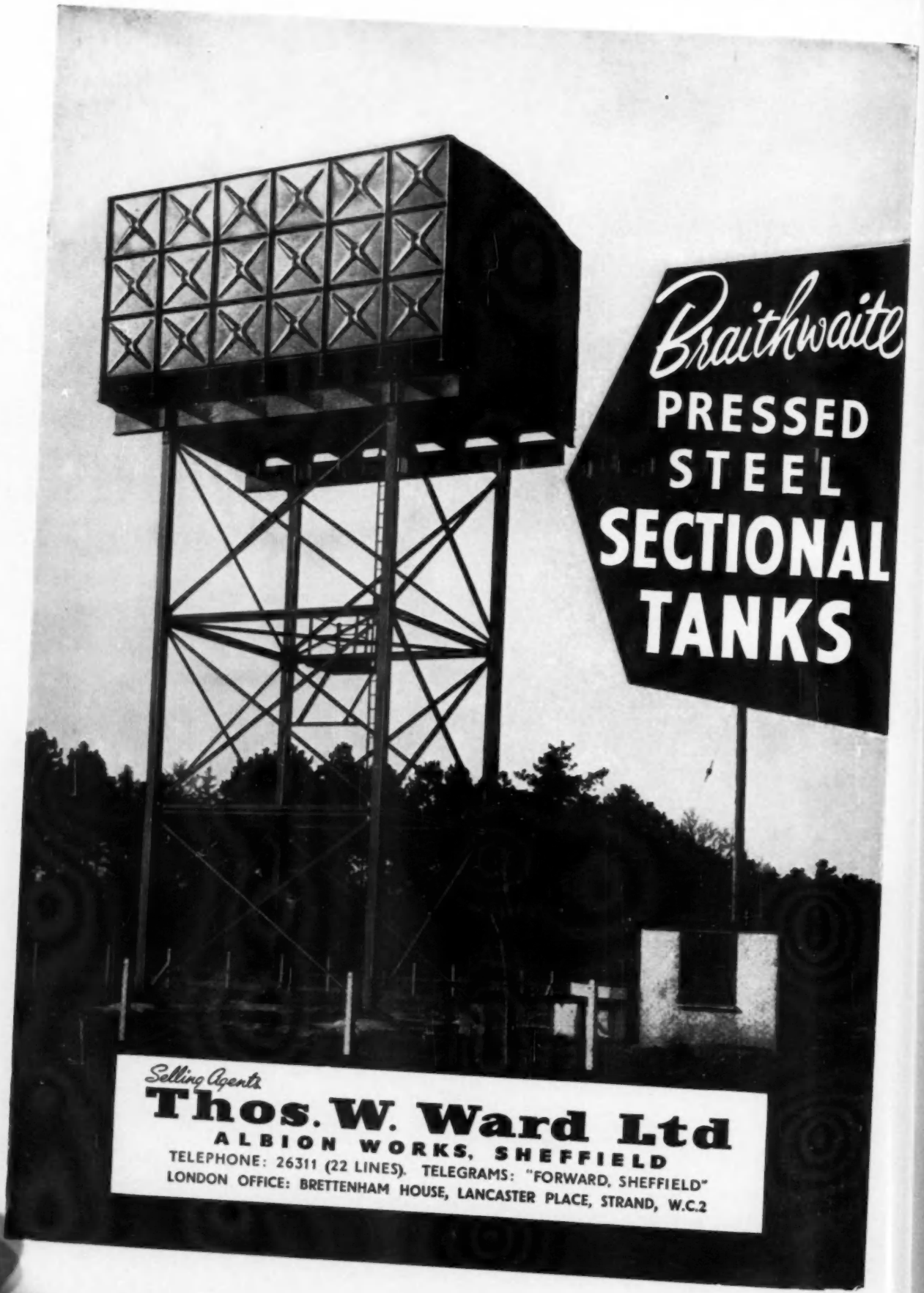
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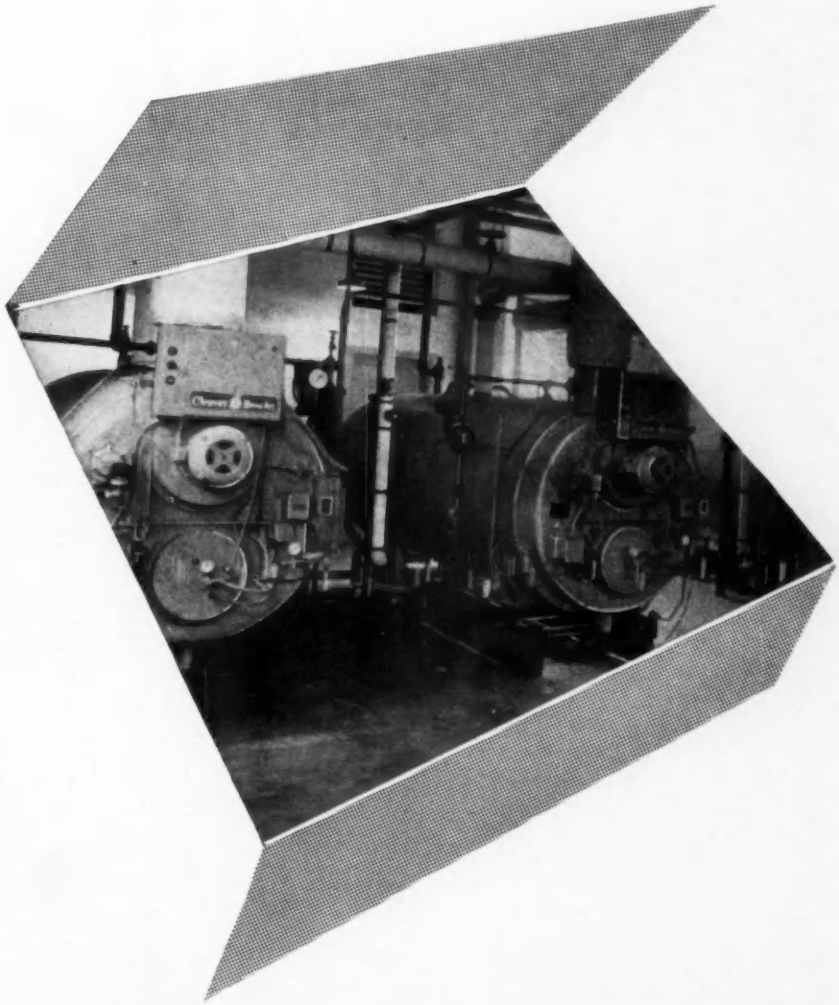


MARSHALLS NOW ANNOUNCE

the World's most advanced PACKAGED BOILERS

Marshalls of Gainsborough have concluded an agreement for manufacture in the United Kingdom of the entire range of Cleaver-Brooks Packaged Steam Generators. The Marshall built steam units will range in size from 500 to 20,500 lbs. per hour, whilst hot water heaters are available with equivalent outputs. Further information can be obtained by writing to Gainsborough.

Cleaver-Brooks Packaged Boilers -by Marshalls of Gainsborough

Thermal Engineering Division, Marshall Sons & Co. Ltd.,
3, Britannia Works, Gainsborough, Lincs. Phone: Gainsborough 2301.

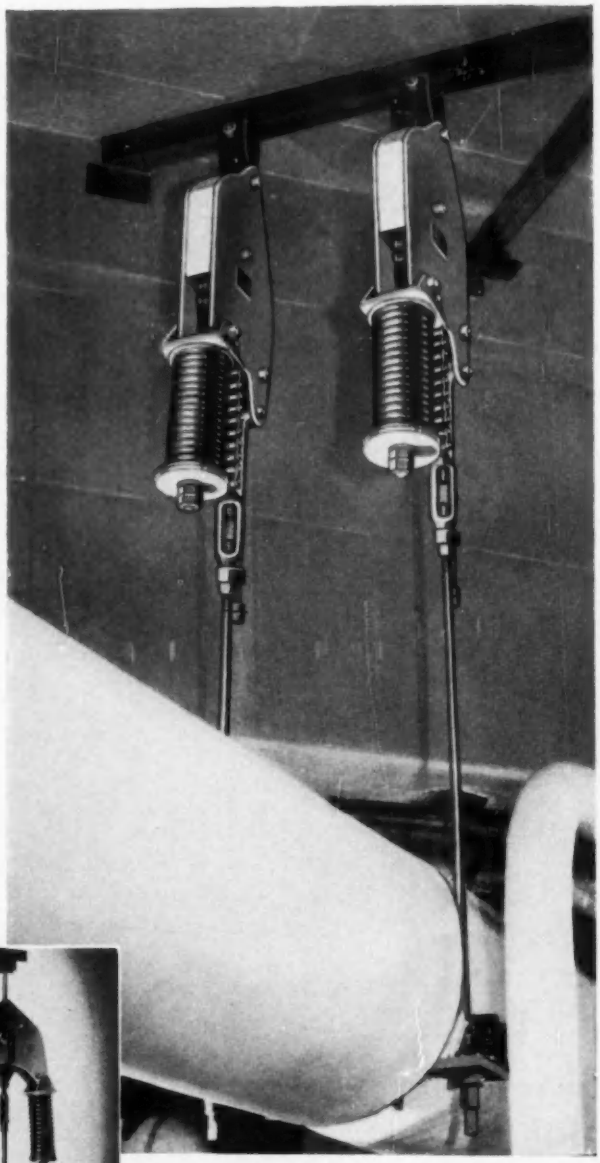
CON-TEN

constant tension supports

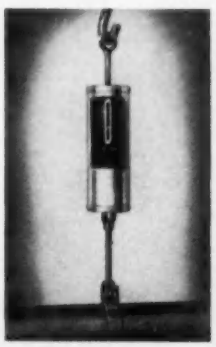
FOR LOADS UP TO 8 TONS
PIPE MOVEMENTS UP TO 18"

High-pressure steam piping is subject to wide variations in temperature, which produce considerable expansion and contraction. Unless the pipe supports can absorb and compensate for this movement, severe stresses are set up which may result in fracture. The " Con-Ten " Pipe Support is designed to cradle any type of piping with constant tension under all conditions, throughout the range of movement. " Con-Ten " is installed, with eminently satisfactory results, in power stations, and oil refineries, chemical and industrial plants throughout the world.

British Patent Nos. 474008 720074 720075 697987 657318
U.S.A. Patent No. 2129320

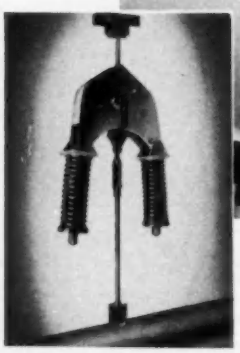


Ferrybridge " B " Power Station. Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts & Lloyds Ltd.



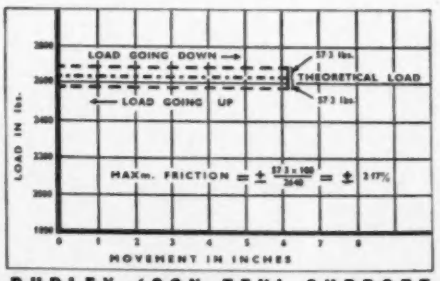
Leibfried Red Top Pipe Supports for loads from 100 to 5,000 lbs. and total travel of 3".

Conventional type " Con-Ten " Supports for loads up to 2 tons with a total vertical movement up to 12".



Duplex " Con-Ten " Supports for load of up to 8 tons with a total vertical movement up to 12". This type is acknowledged as one which produces minimum friction and kinematic variation. It has been specially designed for any applications where exceptional accuracy is demanded.

From graph it can be seen that the maximum friction is equivalent to 2.17% of the applied load.

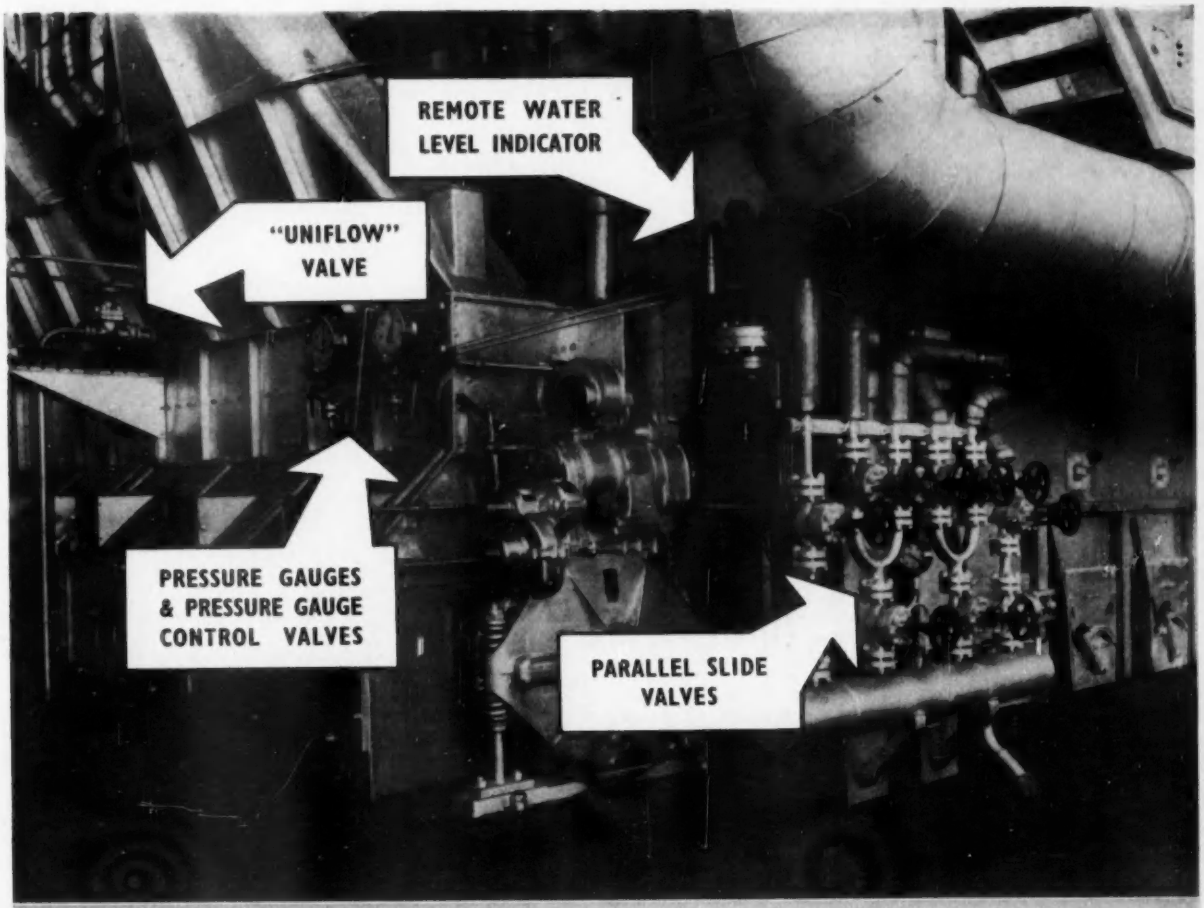

LOAD GOING DOWN →
57.3 lbs.
THEORETICAL LOAD
← LOAD GOING UP
57.3 lbs.
MAXm. FRICTION = ± 57.3 x 100 / 2640 = ± 2.17%
LOAD IN lbs.
MOVEMENT IN INCHES

DUPLEX 'CON-TEN' SUPPORT

BRITISH INDUSTRIAL

ENGINEERING COMPANY LIMITED

CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS.



HOPKINSONS' VALVES AND BOILER MOUNTINGS

The illustration shows an installation with many typical Hopkinson valves and boiler mountings

Hopkinsons have specialised in high-pressure equipment, and have supplied the majority of the high pressure valves and boiler mountings to British power stations, as well as for many industrial plants

Hopkinsons' range of equipment, however, caters for all types of steam raising and usage. in addition to many other duties in industrial process work

HOPKINSONS LIMITED · HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET · STRAND · W.C.2

HV95

CON-TEN

constant tension supports

FOR LOADS UP TO 8 TONS
PIPE MOVEMENTS UP TO 18"

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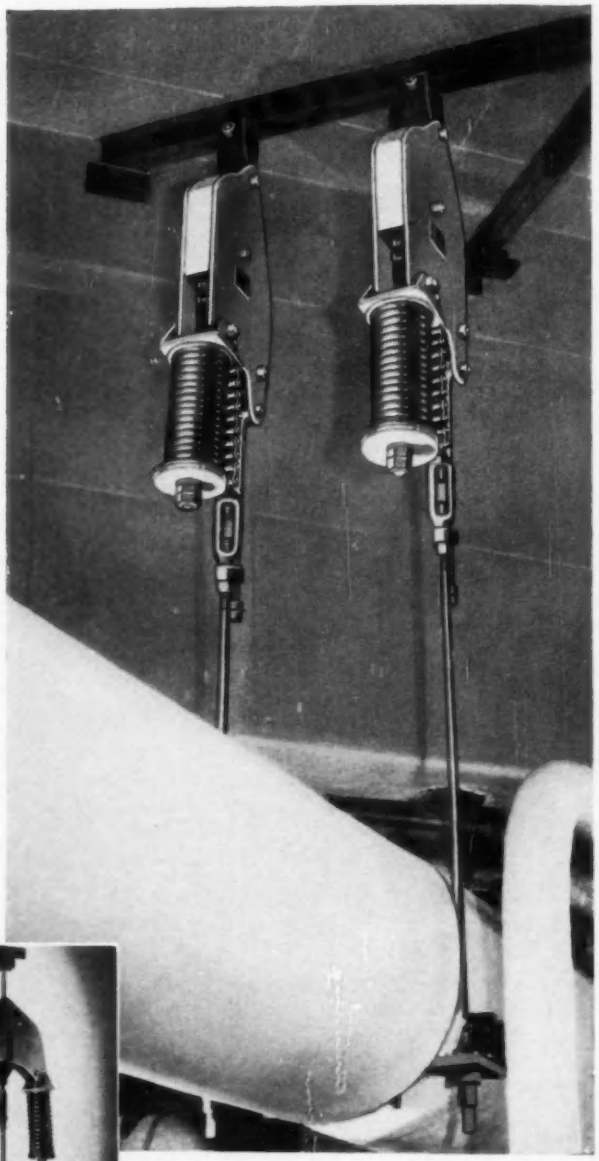

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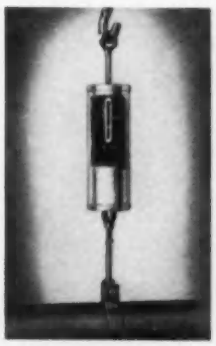

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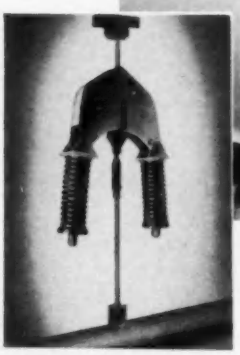

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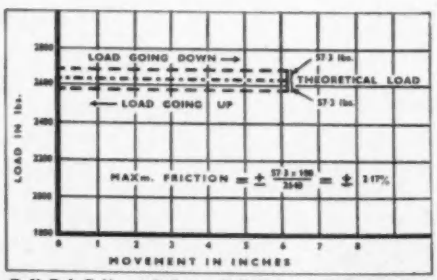

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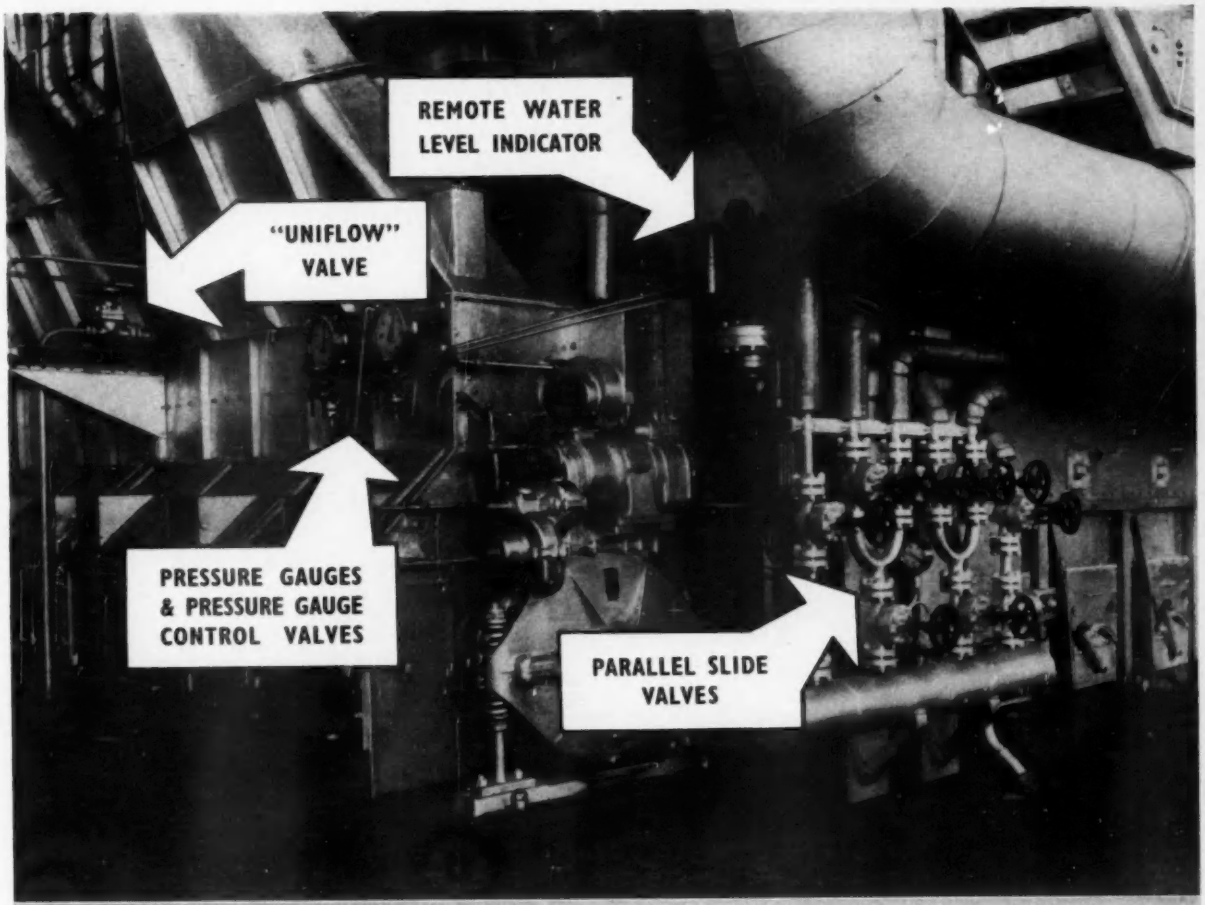
BRITISH INDUSTRIAL

ENGINEERING COMPANY LIMITED

CORONATION WORKS, HAINGE ROAD, TIVIDALE, TIPTON, STAFFS.



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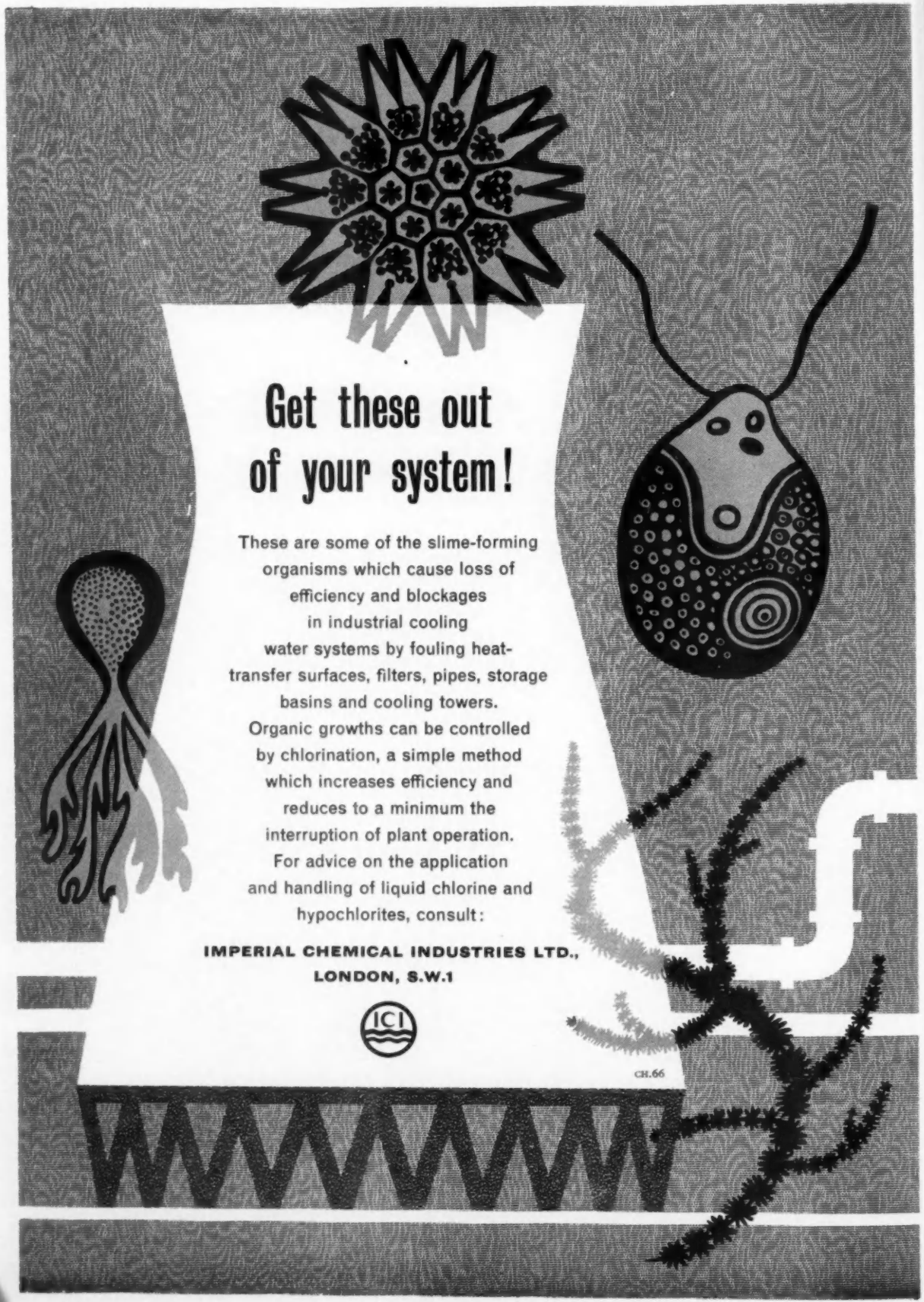

Get these out
of your system!
These are some of the slime-forming organisms which cause loss of efficiency and blockages in industrial cooling water systems by fouling heat-transfer surfaces, filters, pipes, storage basins and cooling towers.
Organic growths can be controlled by chlorination, a simple method which increases efficiency and reduces to a minimum the interruption of plant operation.
For advice on the application and handling of liquid chlorine and hypochlorites, consult:
IMPERIAL CHEMICAL INDUSTRIES LTD.,
LONDON, S.W.1
ICI
CH.66

THORPE MARSH

Precipitator for world's largest boiler unit to be built by

SIMON-CARVES LTD

Removing 12 tons of dust an hour

At the new Thorpe Marsh power station, to be built for the Central Electricity Generating Board, Simon-Carves have been entrusted with the design and construction of the electro-precipitation plant which will have what is believed to be the heaviest duty yet proposed for precipitators on a single boiler unit anywhere in the world.

The unit will have an output of 550 MW and the boiler is expected to produce more than one and a half million cubic feet of flue gas per minute. The plant will remove fine dust, which would otherwise pollute the atmosphere, at a rate of about 12 tons an hour.

PREVENTING AIR POLLUTION

MW per unit	STATION	Gas volume per boiler (cubic feet per minute)
550	**THORPE MARSH**	**over 1,500,000**
120 120 100	PADIHAM 'B' DRAKELOW 'B' WILLINGTON 'A'	over 300,000
60 60 60	HAMS HALL 'C' BOLD 'B' ROGERSTONE	over 200,000
60 30 30 30	CHADDERTON 'B' FLEETWOOD HACKNEY 'B' HUNCOAT	over 100,000

This table of Simon-Carves precipitators for power stations of the Central Electricity Generating Board emphasises the magnitude of the Thorpe Marsh project. High average efficiency on plants already tested enables Simon-Carves to accept this great responsibility with complete confidence.

HIGH EFFICIENCY ELECTRO-PRECIPITATION BY

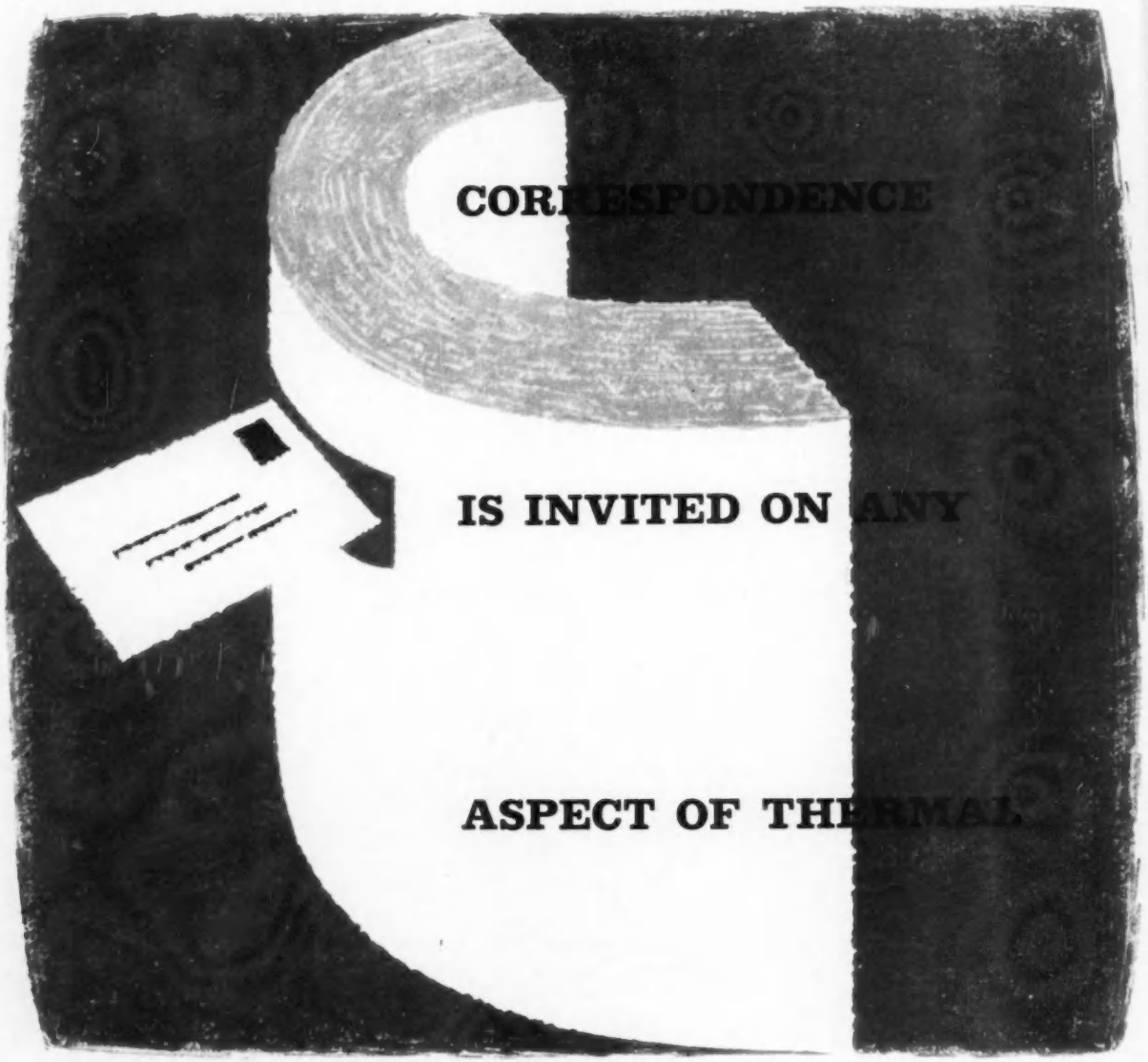
Simon-Carves Ltd

SIMON ENGINEERING GROUP

STOCKPORT, ENGLAND

OVERSEAS COMPANIES *Simon-Carves (Africa) (Pty) Ltd: Johannesburg Simon-Carves (Australia) Pty Ltd: Botany, N.S.W.*

SC193/PS



INSULATION

WE ARE EXHIBITING AT THE
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FUEL
EFFICIENCY
EXHIBITION
NATIONAL HALL
OLYMPIA
LONDON
SEPT 24-OCT 3 1958

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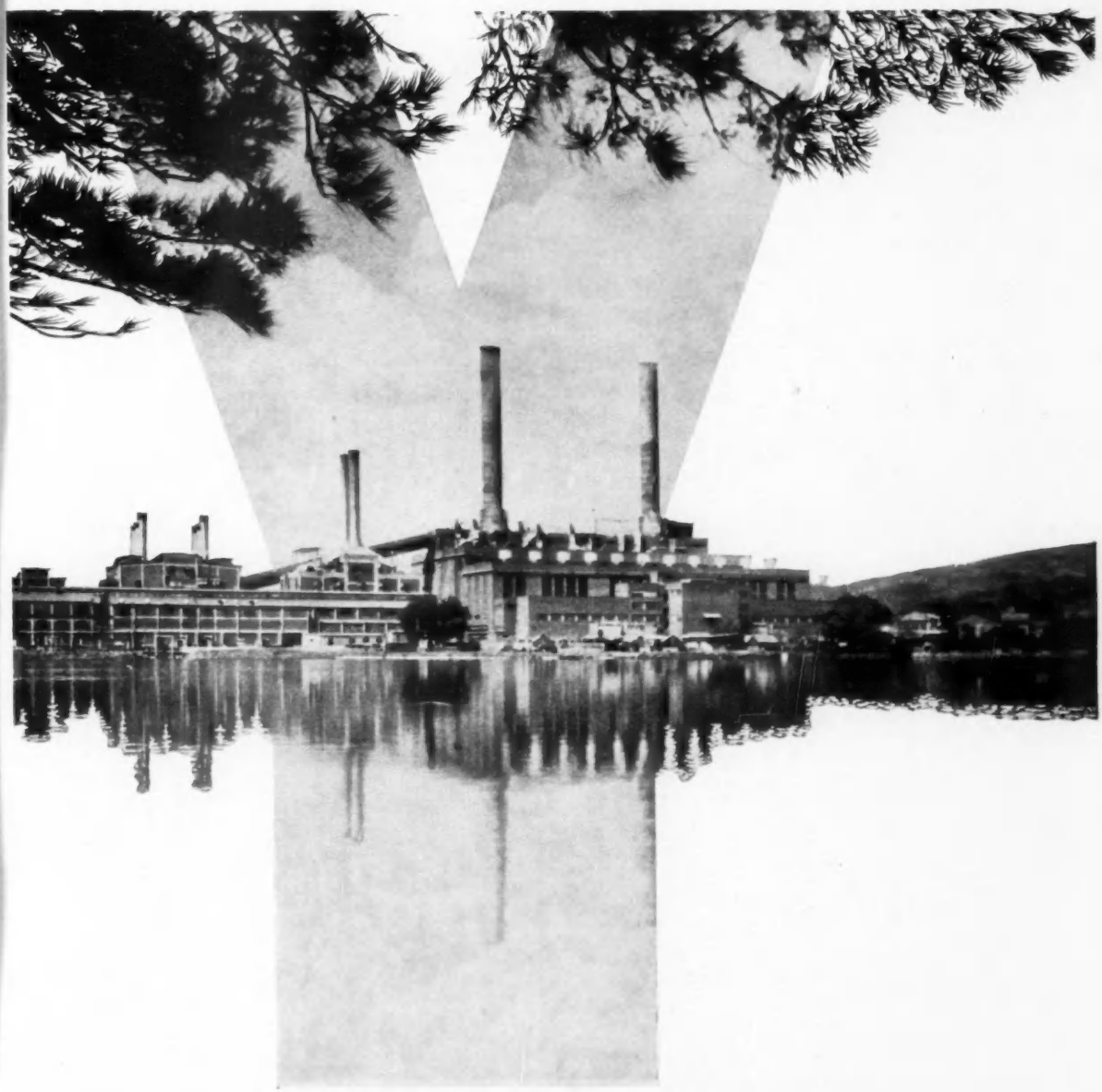
Ground Floor, National Hall

A letter to Newalls has solved insulation problems for many firms over the past fifty-odd years. The same simple step might well be of similar benefit to you.
Technical reports, estimates, performance data—
all preliminary work is undertaken free—and with no obligation whatsoever.

PLEASE WRITE TO **Newalls**

NEWALLS INSULATION CO. LTD., WASHINGTON, CO. DURHAM
A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, BRISTOL & CARDIFF. *Agents and Vendors in most markets abroad.*



Pretoria 'A' and 'B' Power Stations
City Council of Pretoria South Africa

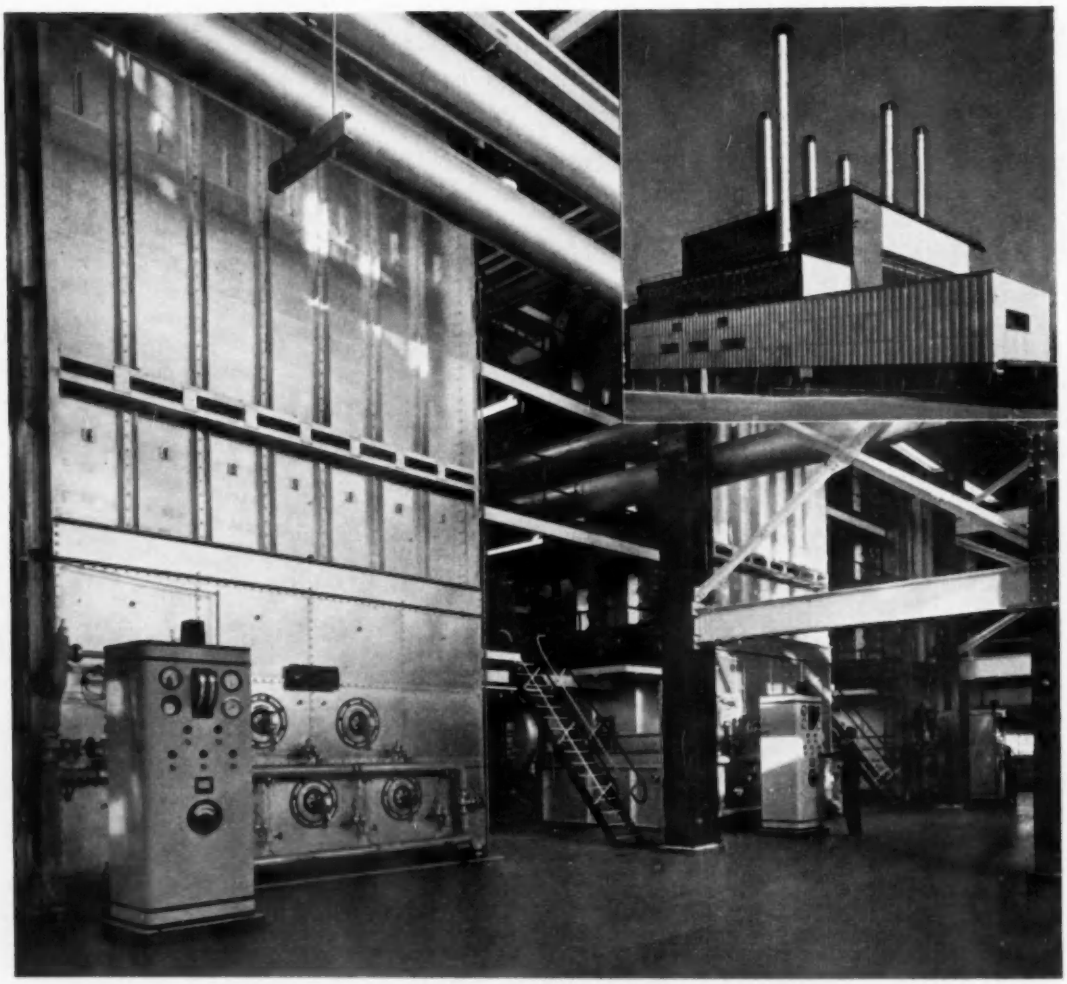
BOILERS BY YARROW

Yarrow & Company Limited
Scotstoun, Glasgow, W.4

LA MONT BOILERS AT VAUXHALL MOTORS

HAVE A GROSS INSTALLED CAPACITY OF

650,000,000 B.T.U's PER HOUR



View on firing floor, with exterior view inset, of the new A.C. Block Boiler House, an integral part of the new extensions at Luton Works

This plant, with 5—70,000,000 B.T.U. High Temperature Hot Water Boilers is the largest of its kind in the world.

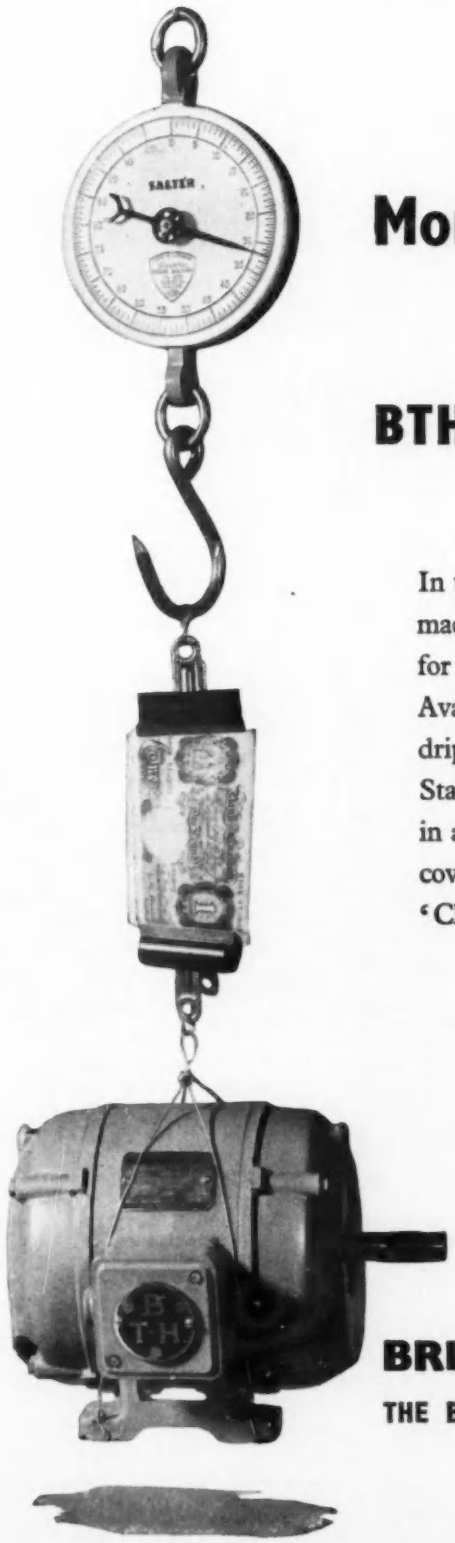
Other La Mont Boilers installed for Vauxhall Motors Ltd. are:

3—50,000,000 B.T.U's PER HOUR AT AB BOILER HOUSE, LUTON
3—40,000,000 B.T.U's PER HOUR AT DUNSTABLE
1—30,000,000 B.T.U's PER HOUR AT DUNSTABLE

LA MONT STEAM GENERATOR LIMITED

HEATHER PARK DRIVE, WEMBLEY, MIDDLESEX

Telephone: WEMBLEY 8821



More power per pound

with the new

BTH VENTILATED MOTORS

In terms of both £ and lb., the new BTH machines offer a substantial saving, horsepower for horsepower, over previous designs. Available in ventilated form, with protected and drip-proof enclosures, BTH Type KN-C British Standard Dimension motors are manufactured in accordance with the new BS 2960 which covers ratings from 1 to 50 h.p. with 'Class E' insulation and 65°C temperature rise.

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Thermix Industries Ltd. are pleased to make available their many years' experience in selecting the most economical and technically suitable system of dust control and recovery for each duty from their extensive range of equipment.

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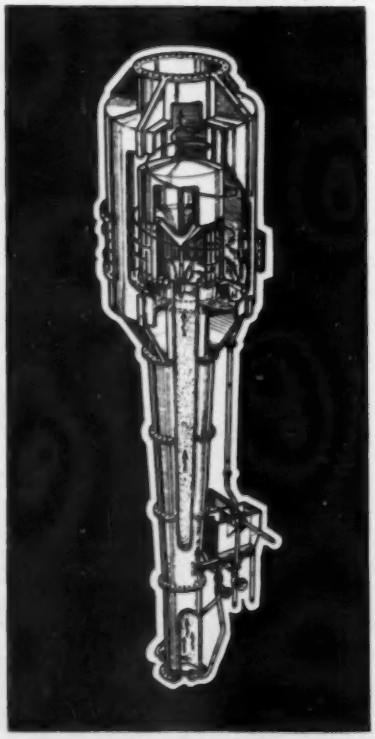

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We should welcome the opportunity to demonstrate our test plant in which clients can observe the behaviour of their materials at pilot plant level.

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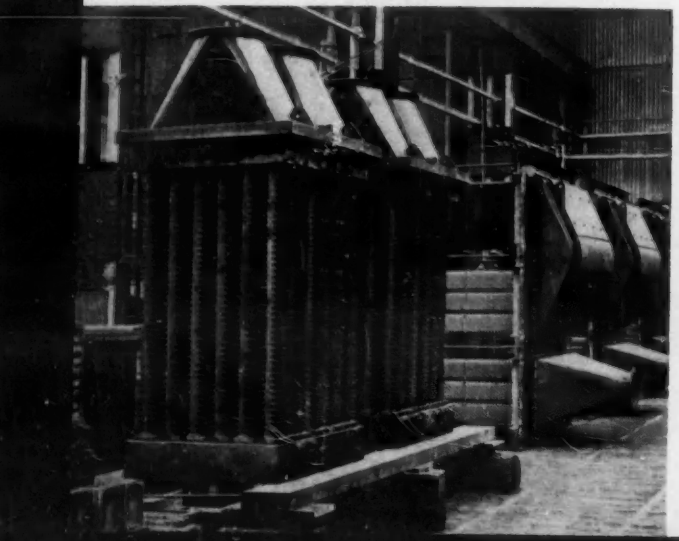

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FOR MANY YEARS we have specialised in the design, manufacture and installation of heat exchange equipment, particularly recuperators, air heaters and economisers of the metallic needle type. These are made by special moulding methods in heat resisting cast iron and in special alloys including 30% chromium iron.

To extend our range into still higher temperature fields, we have now entered into an Agreement with Industrikemiska Aktiebolaget of Sweden to manufacture and sell the "Inka" radiant type pre-heater which is designed for the super-heating of air, steam and combustible gases, up to 875°C.

We shall be pleased to advise on any heat exchange problem and to quote for the most suitable installations.

LEFT AND ABOVE LEFT: *Newton Needle type recuperators.*

RIGHT: *Inka tube bundle being lowered into position.*

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soot blowing

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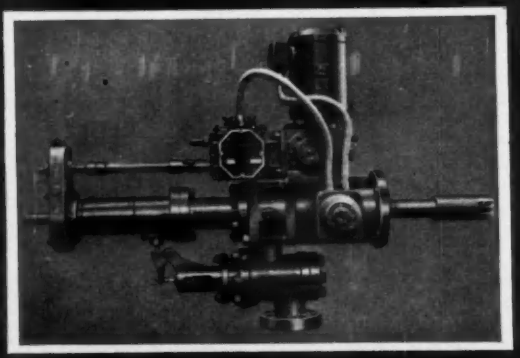
UNIFIED LECTRAMEK CONTROL SYSTEM

most efficient yet devised.

Considerable savings in initial cost and valuable boiler room space have been achieved by this new system of electrical control which works in conjunction with the Clyde Lectramek Soot Blower * - the original blower employing a uni-directional motor. Control is exercised from a small panel which indicates all essential information to the operator.



THE BLOWER: The complete operating cycle is in one motion and is driven through a compact mechanism by a non-reversing motor. When the operating shaft is rotated, the nozzle advances, the steam ports open and, at the same time, rocking motion is automatically transmitted to the nozzle. The uni-directional motor eliminates the bulky contactor gear used with reversing motors and reduces electrical maintenance by being of simpler and more rugged construction.
The reversing motion is achieved *mechanically* on all Lectramek blowers. A limit switch mounted on the gear box and connected to the starter regulates the stopping, starting and number of strokes.

AND THE CONTROL PANEL
Simple controls to operate the automatic sequence are grouped on this small unit which takes up little space on the main boiler control panel.

Further information is given in our publication No. CBL. 1954 which will be supplied on application.

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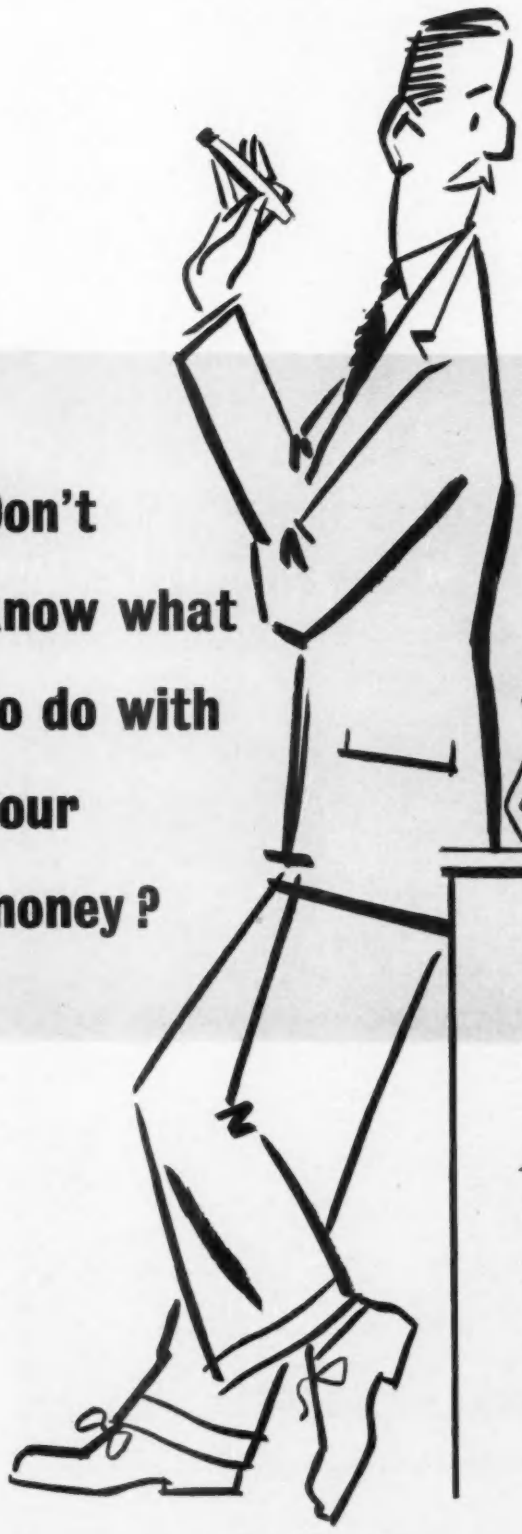
* *Over 5,000 blowers of this type in use all over the world.*



Don't know what to do with your money?

The very best investment for any firm having a boiler plant is to install a Green's Economiser; in a short time it will save enough fuel to extinguish its capital cost and will thereafter provide a handsome dividend throughout its long life.

With fuel costs rising continually, there is no better investment.

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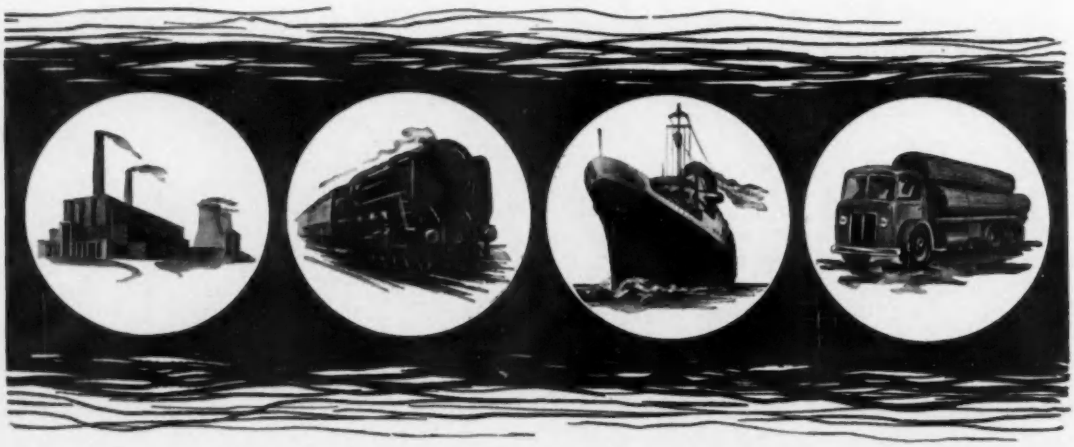

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Refractory concrete similar to Durax No. 2, but with a higher maximum service temperature of 1550°C. (2822°F.)

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A refractory concrete for casting linings and special shapes. Supplied dry. Maximum service temperature 1320°C. (2408°F.)

DURAX No.12
A refractory concrete for use where a lining of high mechanical strength is required. Maximum service temperature 1200°C. (2192°F.)

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Similar properties to No. 2, but more finely ground to facilitate casting thinner sections. Supplied dry. Maximum service temperature 1300°C. (2372°F.)

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AMBERLITE '43' GRADE
Normal hardening insulating concrete of high insulation value and good compressive strength, for furnace and boiler foundations. Maximum service temperature 870°C. (1598°F.)

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PYROCRETE No.3
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Magnesite based refractory concrete. For lining rotary and semi-rotary furnaces melting lead. Maximum service temperature 1600°C. (2912°F.)

Technical advice and assistance on the selection and application of refractories are available on request.

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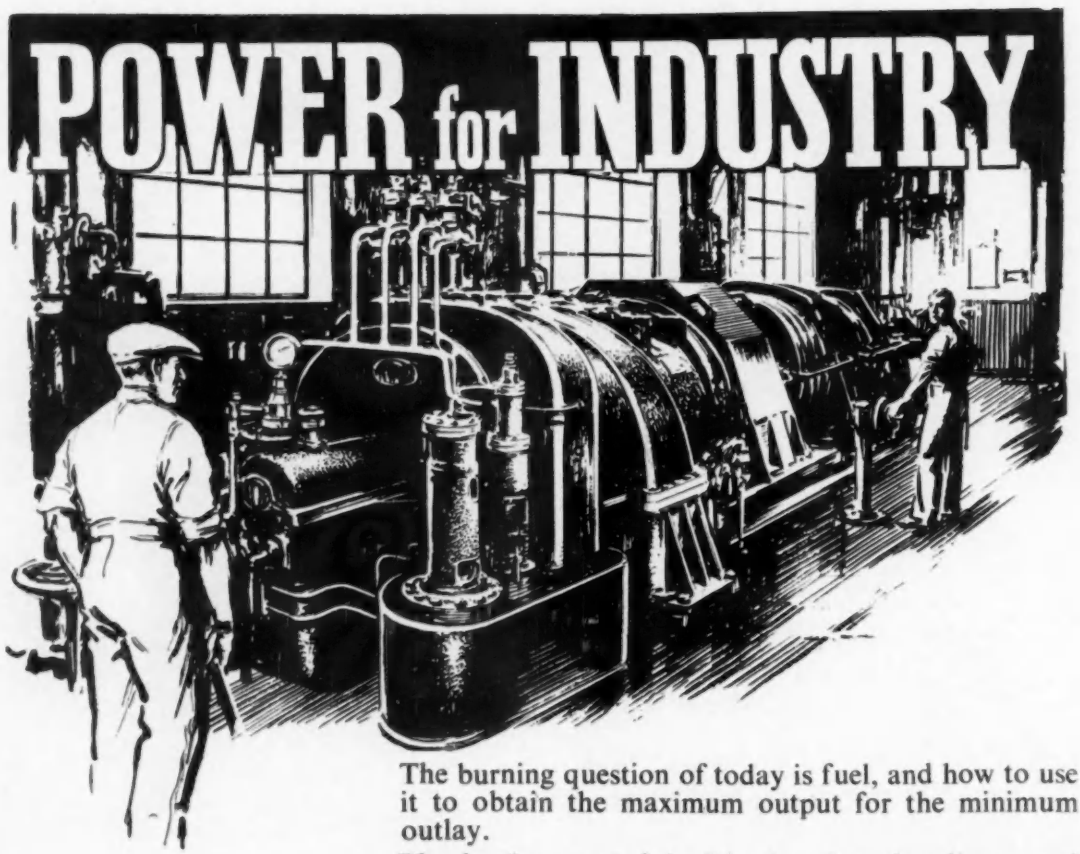
POWER for INDUSTRY



The burning question of today is fuel, and how to use it to obtain the maximum output for the minimum outlay.

The development of the Diesel engine, the oil powered turbine and the increasing use of oil-fired furnaces, have raised many new problems of supply.

Our fleet of modern ships, barges and road vehicles ensure regular and prompt supplies, while our staff are ready to assist customers in achieving maximum fuel efficiency.

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Our Technical Advisory Staff are available for consultation on all problems concerning the most effective use of these fuels ***and in compliance with the Clean Air Act 1956.***

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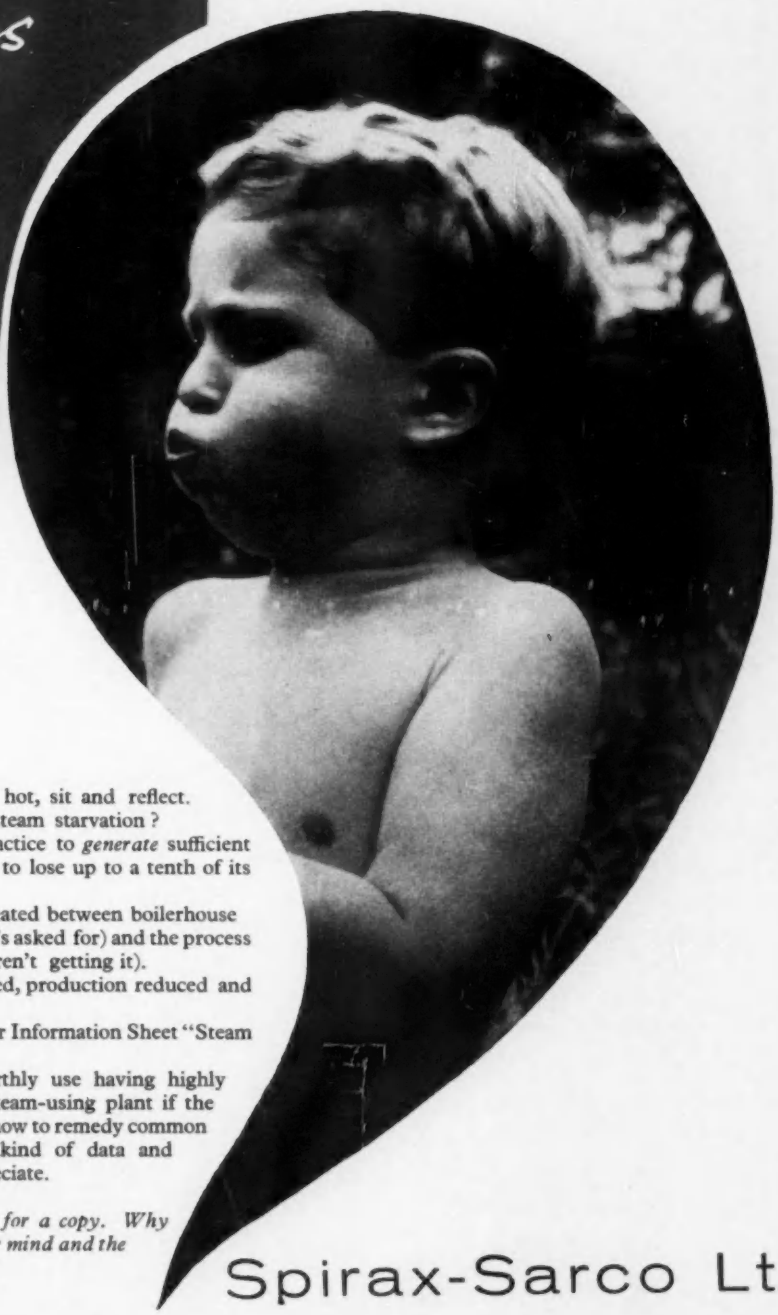
Things getting too hot?



IF STEAM PROBLEMS are getting too hot, sit and reflect. How far are your troubles due to steam starvation?

It is still regrettably common practice to *generate* sufficient steam for the planned purpose but to lose up to a tenth of its heat value *in transmission.*

The wrong sort of heat is thus created between boilerhouse staff (who claim they're giving what's asked for) and the process people (who complain that they aren't getting it).

Fuel is wasted, quality threatened, production reduced and a poor time had by all.

By all, that is, who haven't read our Information Sheet "Steam Distribution."

This maintains that it's no earthly use having highly efficient steam-raising plant and steam-using plant if the link between them is faulty. It tells how to remedy common distribution faults, and uses the kind of data and pictures that busy engineers appreciate.

Sooner or later you're going to ask for a copy. Why not now, when the problem is in your mind and the answers are so readily available?

Spirax-Sarco Ltd

Please send . . . copies of Information Sheet No. 16 "Steam Distribution"

NAME
ADDRESS

EB858

Spirax-Sarco Ltd. Cheltenham, Glos. Phone: Cheltenham 5175-76 London: 28 Victoria Street, SW1 Abbey 6101-3832

Don't let the Clean Air Act outlaw you with smoke like this! One thing is certain—with Ruston Horizontal Thermax boiler plant you are truly in the clear!

Clean Air and steam raising efficiency go together with Ruston Thermax boilers—boilers which radically cut fuel costs and quickly recover capital outlay.

Rustons came first with the three-pass wet back boiler—and still do!

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RUSTON

HORIZONTAL THERMAX BOILERS

evaporations up to 17,500 lb. per hour.

Write for illustrated catalogue, publication 8808X.

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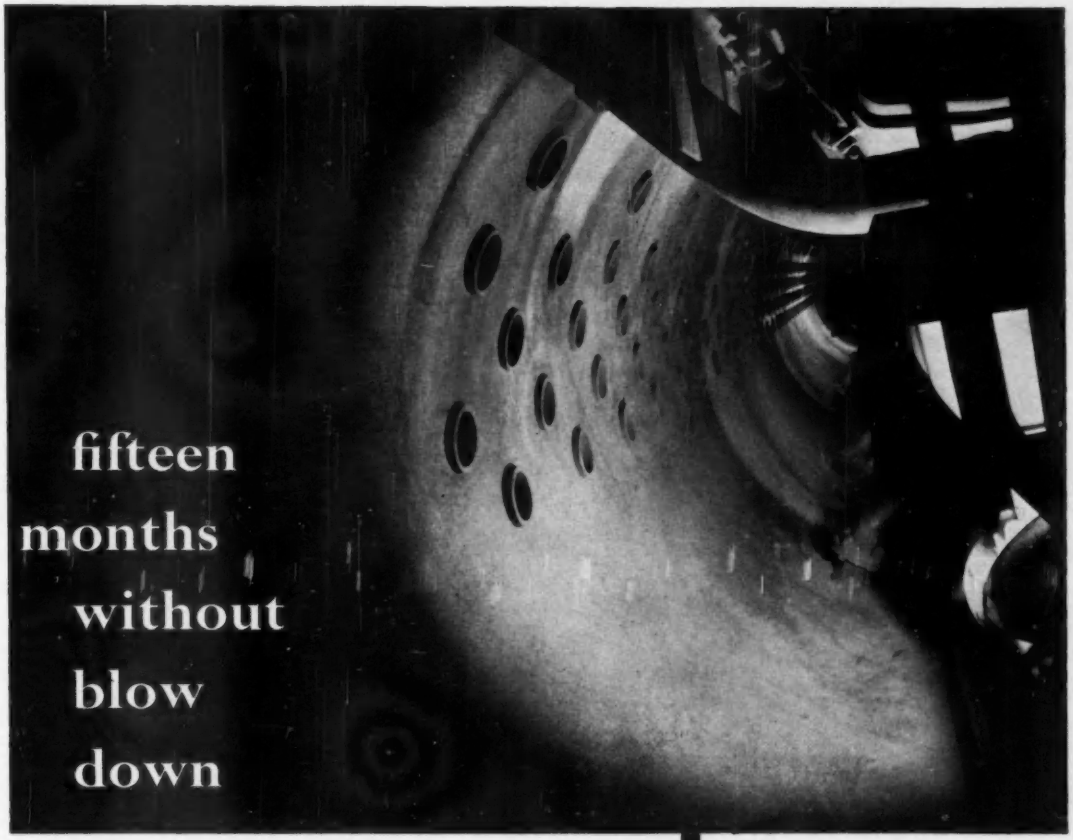

Zerox (35% hydrazine solution) has been used since July 1954 for treating the boiler feed water in Unit 6 at Dunston Power Station, C.E.G.B. (N.E. Division). On 11th March, 1958, Unit 6 was taken out of commission for overhaul having run continuously since 26th November, 1956. During this period—a total in excess of 15 months' operation—no blow down was required at all. Because of the excellent results obtained with Zerox on Unit 6, Unit 5 boiler was also put on to this form of treatment.

This genuine, untouched photograph shows the interior of the boiler drum after being opened up. The cleanliness of the drum interior after such protracted duty is quite remarkable. The deposit in the drum was only 10 oz., black in colour and composed mainly of magnetite and copper oxide.

From this factual case history, the advantages of Zerox are clearly established. Whiffens, who are the sole manufacturers of Zerox, will be happy to provide any technical information or advice you may require concerning its properties, its economies, its performance and its application. Write for Leaflet No. H/H/2.

ZEROX

If you are interested in Zerox and the treatment of boiler feed water, you will be interested also in the proceedings of the International Conference on Hydrazine and Water Treatment held at Bournemouth in May 1957. The fully bound book of the Conference is available from the organisers, Whiffens, price one guinea, plus 2s. 6d. postage and packing (in the U.K.)

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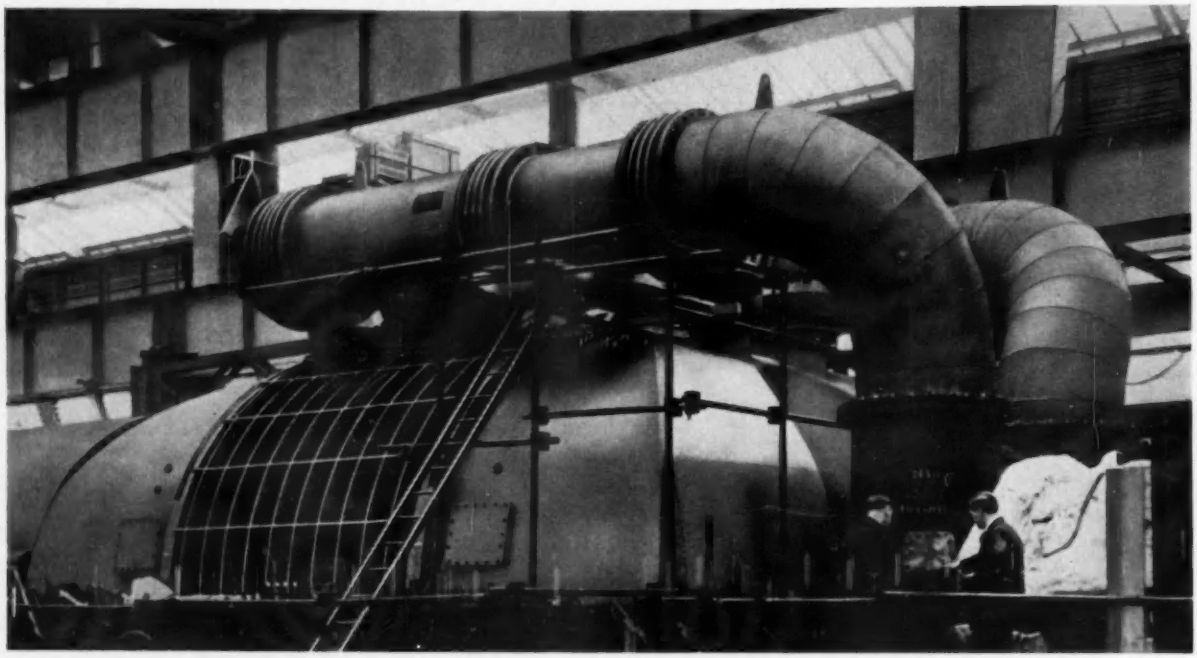


The I.P.-L.P. line

the first 200 MW for Canada nears completion . . .

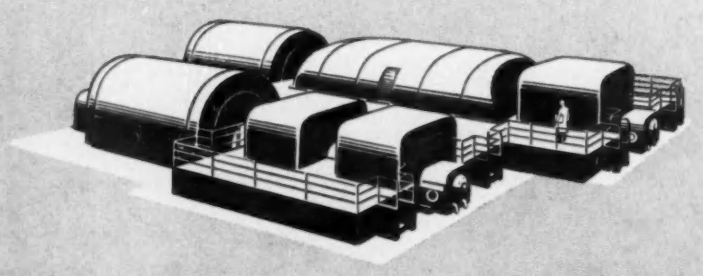
There are four of these 200 MW cross compound turbo-generators to be supplied to Canada for installation in the Hydro Electric Power Commission of Ontario, Richard L. Hearn generating station at Toronto. The first of these four machines is now nearing completion. They will be part of the largest power station in the world to install *all Parsons turbo-generators*—a total of four 100 MW sets and these four 200 MW sets.

PARSONS

TURBO-GENERATORS

. . . as preparations go ahead to build the first 300 MW

Two 300 MW cross compound turbo-generators have been ordered by The Hydro Electric Power Commission of Ontario for a new power station to be built at Lakeview, near Toronto. These are the largest machines to be ordered by Canada and they will operate with steam at 2,350 lb/in² pressure 1,000°F temperature and reheat to 1,000°F.



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Engineering and BOILER HOUSE REVIEW

THE OLDEST ESTABLISHED STEAM ENGINEERING PUBLICATION

AUGUST 1958

VOLUME 73. No. 8

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The Editor will be glad to receive and consider original contributions, correspondence, etc., of a suitable nature for publication. Stamped and addressed envelopes should be enclosed for the return of any matter considered unsuitable

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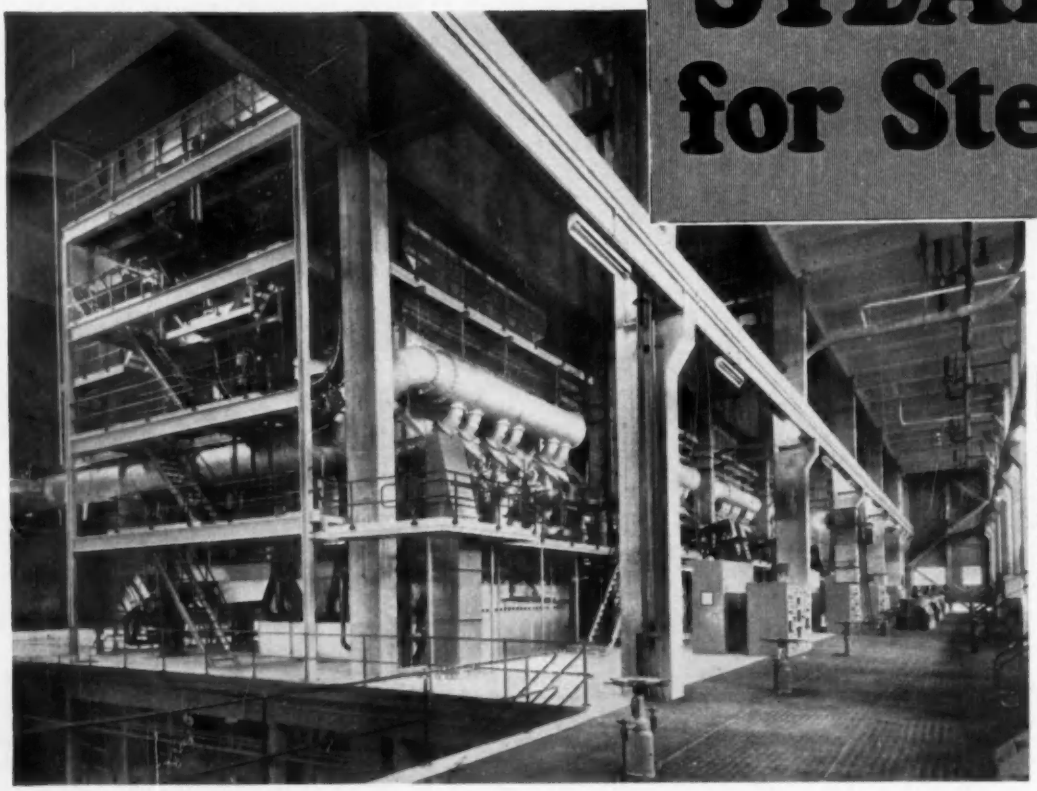
STEAM for Steel



EXHIBITIONS

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FUEL EFFICIENCY EXHIBITION

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UNIVERSAL & INTERNATIONAL EXHIBITION BRUSSELS

APRIL 17 - OCT. 15
BRIT. INDUST. PAVILION
STAND J.

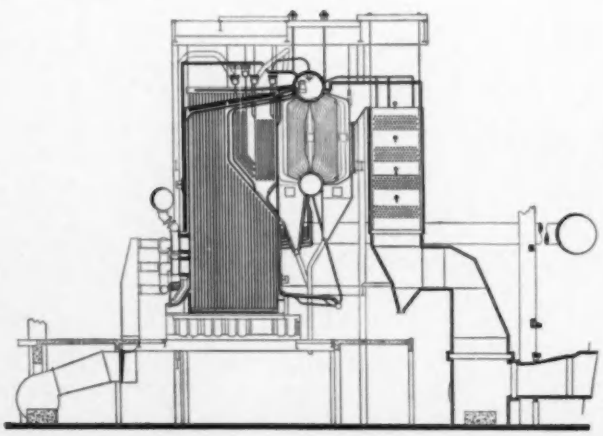
BABCOCK & WILCOX Ltd. are proud to have had an important part in the equipment of the new Colvilles £20,000,000 coke oven, blast furnace and steelmaking plant at Ravenscraig, Motherwell, Scotland.

They share a mutual interest in this great plant, as they are themselves considerable users of Colvilles steel for the manufacture of high-pressure boiler drums, and pressure vessels for the oil and chemical industries.

At the new Ravenscraig works, four Babcock Bi-drum boilers, each with an evaporation of 125,000 lb. steam/hr. M.C.R., at 425 lb./sq. in. and 820°F., supply high-pressure steam for electrical power generation and for the operation of turbo-blowers serving the blast furnaces. Provision is also made to supply steam for process purposes. The main fuel for the boilers is blast-furnace gas with a G.C.V. of approximately 98 B.Th.U/cu. ft., at a pressure of 10 in. w.g. Oil burners are also provided for auxiliary or alternative oil-firing and provision has been made for possible future stoker-firing to use coke-breeze from the works coke-ovens.

The contract placed with Babcock & Wilcox Ltd. by The General Electric Company Limited, main contractors for the electrical power plant, covered also the supply of much of the auxiliary plant including the oil-firing installation, oil piping, high-pressure pipework and valves in the boiler-house — including piping to turbo-alternators and turbo-blowers—Bailey automatic boiler control equipment, oil storage and service tanks and steel self-supporting chimneys—a good example of the comprehensive service offered by Babcock & Wilcox Ltd. to industrial steam-users.

BABCOCK
STEAM-RAISING PLANT



Sectional arrangement of one of the 125,000 lb. / hr. Babcock Bi-drum boilers at the Ravenscraig works.

BABCOCK & WILCOX LTD., BABCOCK HOUSE, 209 EUSTON ROAD, LONDON, N.W.1

Engineering and
BOILER HOUSE REVIEW

AUGUST 1958

VOLUME 73 No. 8

NUCLEAR POWER PROBLEMS

UNTIL a month ago, Great Britain could rightfully claim to be the only country that had adopted a programme of development of nuclear power generation that was designed solely for industrial purposes. Furthermore, a good deal of what has been said and written about British progress in developing the technique has, perhaps, led to the creation of the popular impression that, so far, everything has resulted in unqualified success. Much of this popular impression has no doubt, been based mainly upon the successful operation of Calder Hall " A "—the first call upon which is for plutonium, with the production of electricity as a by-product. But nevertheless, the rapid progress made in both design and constructional work on plant for the first four purely commercial nuclear power stations calls for much credit upon all personnel concerned.

It was hoped that these stations would be successful in operation in accordance with their individual schedules; and that apart from ordinary problems likely to be encountered, and assuming that no other factors would have to be considered, success would continue uninterruptedly. Unfortunately, the problem is not quite so simple as that, as one complication has been introduced in the statement made recently by the Minister of Defence that " to provide insurance against defence needs, certain of the civil nuclear power reactors now in the early construction or design stage are being modified so that the plutonium produced as a by-product is suitable for use, if the need arises, for military purposes." It is understood that a start has already been made on adapting the design of the fuel charging and discharging equipment for the reactors under construction at Hinkley Point. Hunterston is also to be used for this purpose, though very little amendment in design is necessary in this case. But at the first two stations in the programme—Berkeley and Bradwell—constructional work has progressed too far for any alteration to be made. Thus it seems that these will remain as the only two entirely civil nuclear power stations in the country.

There is no reason to doubt that so important a decision is a political one which is dictated by the national interest; and it may be likely to result in unwarranted repercussions on the development of nuclear power on a purely commercial basis. However, the decision must be accepted, although it is perhaps unfortunate for several reasons. It is generally concluded that the change would result in higher cost of the electricity produced at these stations, because it reduces the " burn-up " period of the uranium fuel elements, when hitherto the aim has been to extend that period and thus obtain the maximum output from the fuel. What the extra cost would be is not exactly known; but in an adjournment debate in the House of Commons a week or two ago, the Parliamentary Secretary to the Ministry of Power (Sir Ian Horobin) said that the cost of the modifications was unlikely to exceed 1 per cent. of the cost of the stations concerned. Since this cost would be borne by the Government, it would not affect the cost of the civil nuclear programme. The additional operating cost that would be incurred by the electricity authorities if the facilities were used would be small, and would also be borne by the Government. Sir Ian Horobin further emphasised the fact that he would be sorry if the idea gained ground that they were making fundamental changes in the reactors concerned, which would make them hybrids and that their operation would not remain a perfectly genuine and economic method of producing electricity.

In any case the whole requirement must be regarded as one of necessity—even if that necessity is an evil one—and one which may cause the loss of a considerable amount of valuable technical experience for engineers and scientists in the operation of nuclear power plants under conditions of commercial loading, and where their main task would be to pursue an intensive research and development programme aimed at reducing both capital and operating costs of the gas-cooled graphite-moderated reactor. Against this, the Minister of Power has pointed out that no delay is expected in the completion of the nuclear stations already under construction, of which, and as we have already mentioned, Berkeley and Bradwell escape the new policy. The whole requirement is both complex and urgent, and the decision taken—unfortunate as it may be in affecting the original nuclear power programme—is surely one that will result in the demands in question being met (should the necessity arise), more rapidly and less costly than would be the case if new plants, expressly designed for the purpose, were decided upon.

Points and Pointers

BRITISH INDUSTRY AND EUROPEAN TRADE

It is refreshing to learn that British industry has taken a lead in order to promote trade in Western Europe by founding a permanent organisation to look after its interests. Known as "The Britain in Europe Committee" (incorporated as a company limited by guarantee), a group of leading figures from all sides of industry, finance and commerce have come together "to stimulate interest in Britain's participation in the proposed European Free Trade Area." We understand that the main function of the committee will be to undertake or sponsor original research on European economic integration and to make known its results. It appears that they will also provide specialised information and documentation as well as initiating or supporting courses, lectures and meetings. Their basic objective as stated in their terms of reference, is "to promote an understanding in industry in general of the issues likely to arise from British participation in the European Free Trade Area and to link this understanding with the initiatives in the political sphere necessary to secure ratification of the appropriate Treaty of Convention." The chairman of the Britain in Europe Committee is Sir David Kelly. The chairman of the executive committee is Mr. Lawrence Robson, chairman of Associated British Engineering and the vice-chairman is Mr. Ernest Jones, the president of the National Union of Mineworkers. The engineering and metal industries' representation numbers 15 out of 32 representatives of manufacturing companies (the membership, including trade associations and trade unions, totals 56). It suggests that for many of the leaders in the industry the free trade area is an opportunity they do not wish to miss.

ANGLO-AMERICAN AGREEMENT ON ATOMIC ENERGY

A White Paper (Cmnd. 470, price 6d.) has been presented to Parliament detailing the agreement reached between the governments of the U.K. and the U.S.A. on co-operation in the military use of atomic energy. Generally, the agreement provides (but not unreservedly) for exchanges of information, materials and equipment. With regard to information, the terms cover the planning of defence, training, evaluation of the abilities of potential enemies, development of "delivery systems compatible with the atomic weapons they carry," research on military reactors, and matters of weapon design and "fabrication." The government of the U.S.A. also undertakes to sell "one complete submarine nuclear propulsion plant with such spare parts therefore as may be agreed." Reactor cores or fuel elements for replacements will be supplied for ten years from the coming into force of the agreement, as will also quantities of uranium enriched in U^{235}. However, atomic weapons (not the transporting or propulsive means) are specifically excluded. The terms of the agreement include a proviso that nothing in it shall be interpreted as a bar or restriction on consultation or co-operation in defence by either party with other nations or international organisations. But secret information is, of course, not to be passed on to any third party, and policies on secrecy classification are to be agreed. Patent and royalty rights are also set out in the White Paper. The agreement will come into force when each government has received from the other written notice that it has complied with all that is statutorily and constitutionally required. Termination is to be by mutual consent, or by specified form of notice on either side.

APPRENTICE AWARDS

A few weeks ago at a ceremony at Rugby, more than 200 engineering apprentices of The English Electric Company Ltd. received merit awards and indentures from Sir John Woods, a director of the company. On the same occasion, the examination results were announced of fifty of the company's engineering students who are taking external degree and certificate courses at the Rugby College of Technology and Arts. In his annual report, Mr. L. Du Sautoy, chief of personnel and training at the company's Rugby works, announced a new kind of course for craft apprentices. He said that, in an attempt to reduce the wastage rate of craft apprentices who embarked upon City and Guilds courses but never completed them, The English Electric Co. Ltd. had introduced at Rugby a sandwich course made up of three months, full-time study each year at the technical college, instead of the existing system of a day a week throughout the five years' apprenticeship. Mr. Du Sautoy said that the first group of apprentices had now completed their period of study at the Rugby College of Technology; the results, which so far were most encouraging, were being watched with interest by many educational authorities.

STEADY SPREAD OF "SANDWICH" COURSE SYSTEM

The "sandwich" course as a means of providing training for engineers has in many ways proved to be very suitable. A list of approved "sandwich" courses in technical colleges published by the Ministry of Education recently (H.M.S.O., price 1s. 6d.), gives details of 263 courses of this type to be held during the 1958-59 session. This represents 65 more than were approved for last year. The new list includes the latest information concerning courses planned to start in the coming session. We understand that there are now 144 courses (21 more than last year) available at Colleges of Advanced Technology and Regional Colleges. About a third of these courses lead to degrees or diplomas in technology, and the remainder to other high qualifications which in many cases give exemption from the examination requirements of professional bodies in the field of science and technology. Sandwich courses offered at other technical colleges have also increased from 75 to 118. Many new subjects are offered including not only various branches of engineering, but also glass technology, business administration, foundry work and pattern making, telecommunications and many others. About half the

courses in this group are intended to lead to the Higher National Diploma ; the rest cover a wide variety of qualifications including a number below advanced level. The importance of the sandwich course—alternate periods of full-time study in college and experience in industry—has long been recognised by the Government as a means of producing the technologists the country so badly needs at the present time. The system is now reported to be spreading to other fields, and the continual growth in number and variety is evidence of their increasing popularity and standing among both employers and students alike.

BABCOCK & WILCOX COLLABORATION

It is announced by Babcock & Wilcox Limited, London, that after many years of co-operation with the Babcock & Wilcox Company of America in the design of conventional steam-raising plant, these two companies have now extended their technical collaboration into the nuclear power field. Babcock and Wilcox Limited has an experience extending over some ten years in nuclear engineering, in collaboration with the United Kingdom Atomic Energy Authority. It collaborated with the Authority in the design, construction and erection of all the specialised steam-raising plant for the Calder Hall and Chapelcross atomic power stations of the Atomic Energy Authority, and, as a member of the English Electric-Babcock & Wilcox-Taylor Woodrow Atomic Power Group, is currently engaged in the construction for the Central Electricity Generating Board, of the 500-MW nuclear power station at Hinkley Point. The Babcock and Wilcox Company, New York, became involved in the American nuclear programme more than ten years ago, and has co-operated closely with the United States Atomic Energy Commission on nuclear developments and has designed and constructed many pressure vessels and heat-exchangers for the American programme. The company is also the main contractor for the design and supply of the pressurised-water thorium converter reactor, and the steam-generating equipment for the Indian Point power station of the Consolidated Edison Company of New York. Another important contract obtained, is that for the supply of the complete propulsion plant for the world's first nuclear-powered merchant ship *Savannah*, which will incorporate a pressurised-water reactor. The company's production facilities include the first privately-built factory for the fabrication of nuclear fuel elements and a laboratory for the testing of reactor cores under critical conditions.

MISHAP AT CALDER HALL

It is, of course, a serious matter when a mishap occurs to a turbo-alternator in a " conventional " power station ; but when the machine is installed in a nuclear station it is certain to cause a considerable amount of public alarm and misunderstanding as to the nature of the accident, and to its effects both injurious and otherwise which might possibly ensue when atomic nuclei break up. It is particularly unfortunate, therefore, that an accident should have occurred to No. 5 turbine at Calder Hall " B " station at about 7-30 p.m. on Saturday, June 28th. Fairly extensive damage was caused to plant, but luckily none of the twenty personnel who were working in the immediate vicinity were either killed or injured. Apparently, some fragments of the machine were hurled over a distance of about a quarter of a mile, and, parts of the turbine house were wrecked. The resulting fire was promptly dealt with by the station's own fire brigade, and the turbine house was further flooded by water escaping from pipes fractured by the explosion. All this happened as the climax to running tests that were being imposed on the particular set, and thus the accident was " purely mechanical." The United Kingdom Atomic Energy Authority says that it is not certain as to the actual cause, but it would appear that a valve or governor jammed and, in consequence, caused over-speeding of the machine during the test. It is also officially stated that no increase in radioactivity had been observed. So it may be presumed that, even if any part of the coolant circuit was punctured (which, according to early reports, appears to be unlikely), no burst slugs were noticeably contaminating any gas that may have escaped and, therefore, there was no question of danger from radioactivity. The investigation of the accident, which has been taken over by Mr. P. T. Fletcher, deputy managing director of the Industrial Group, U.K.A.E.A., will probably lead to some interesting conclusions, and will show that the accident was in no way influenced by the association of the particular turbo-alternator with a nuclear plant.

A.E.I. REORGANISATION

The British Thomson-Houston Company have announced the appointment of several further executives to the newly-formed A.E.I. Heavy Plant Division, which is to be managed by B.T.H. Details of these appointments, and also of other appointments under the group reorganisation are made elsewhere in this issue. All these appointments mark a further stage in a long-term plan to reorganise the A.E.I. Group on the basis of type of product. The whole scheme was dealt with at some length by the chairman, Lord Chandos, in his statement at the annual general meeting on April 9th last, of Associated Electrical Industries Limited, and was referred to in the May issue of this journal. During 1957, the first stage of the reorganisation was completed, and by the end of the year, the four groups within the company—British Thomson-Houston (with A.E.I. Lamp and Lighting Company, Birlec and Hilltop Foundry Company) Metropolitan-Vickers Electrical Co. (with Ferguson Pailin and Sunvic Controls), Siemens Edison Swan and the overseas Group—were stated to be working smoothly. The three principal operating companies—British Thomson-Houston, Metropolitan-Vickers Electrical and Siemens Edison Swan—will manage various A.E.I. divisions under a policy laid down by the board of A.E.I. These companies are to remain the organisations through which general A.E.I. policy is carried out ; but some of the executive work will be the responsibility of the various divisions. Initially, two divisions have been formed, and these became operative on July 1st. These are the Turbine-Generator Division managed by Metropolitan-Vickers, and the Heavy Plant Division managed by British Thomson-Houston. While many of the established and well-known designs of these two companies will continue to be available for some years, they will eventually be superseded by a complete range of A.E.I. designs.

The Flow of Steam/Water Mixtures Through Sharp-Edge Orifices

By D. CHISHOLM, Ph.D., B.Sc.

These notes show that from theoretical considerations, parameters are developed which correlate data for the flow of steam water mixtures through sharp-edge orifices. Equations are obtained which readily permit, by calculation the prediction of flow under such conditions.

STEAM-WATER mixtures are commonplace in industrial plant where they can occur, for example, through the heating of water in a boiler, or during the "flashing" of saturated water to steam during some throttling process such as the draining of condensate from heaters. While a number of investigators have carried out experimental work on the flow of steam-water mixtures through sharp-edge orifices, no satisfactory theory or analysis has been developed which permits prediction of flow under such conditions. The following development leads to equations which, for the great majority of the available data, predict flow rates within ± 10 per cent. of the measured values.

Theory

The various cross-sections referred to in this development are indicated in Fig. 1; for convenience, linear dimensions are shown as representing areas. The cross-sections of the liquid and vapour phases at their vena contracta are respectively A_L and A_V, and it should be noted that it is irrelevant to the following argument whether or not these cross-sections occur at the same distance from the nozzle. Further, while complete separation of the phases has been shown in Fig. 1, the following theoretical development is independent of the flow distribution.

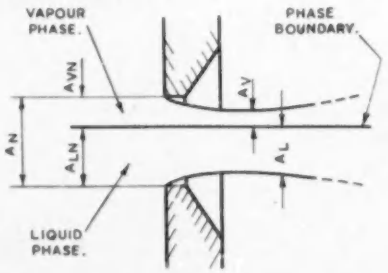


Fig. 1. Phase distribution through a sharp-edge orifice.

Consider the liquid phase: from the continuity equation

$$W_L = A_L \cdot U_L \cdot \rho_L \qquad (1)$$

where the cross-section (A_L), velocity (U_L), and density (ρ_L) are those occurring at the vena contracta. Designating α as the ratio of the velocity at the vena contracta during two-phase flow to the velocity during single phase flow for the same orifice pressure drop, we have

$$U_L = \alpha \cdot U_{LN} \qquad (2)$$

Where C_L' represents the ratio of the liquid cross-section at the vena contracta (A_L) to that at the nozzle throat (A_{LN}) occupied by the liquid,

$$A_L = C_L' \cdot A_{LN} \qquad (3)$$

Combining Equations 1 to 3

$$W_L = C_L' \cdot \alpha \cdot A_{LN} \cdot U_{LN} \cdot \rho_L \qquad (4)$$

A similar equation is obtained for the vapour

$$W_V = C_V' \cdot \beta \cdot A_{VN} \cdot U_{VN} \cdot \rho_V \qquad (5)$$

If W_{LN} is the single-phase liquid flow corresponding to the two-phase pressure drop and a contraction coefficient of unity, and A_N is the nozzle throat area, then

$$W_{LN} = A_N \cdot U_{LN} \cdot \rho_L \qquad (6)$$

Similarly for the vapour

$$W_{VN} = A_N \cdot U_{VN} \cdot \rho_V \qquad (7)$$

The nozzle throat area is the sum of the areas occupied by the liquid and the vapour, i.e.

$$A_N = A_{LN} + A_{VN} \qquad (8)$$

and the dryness fraction is defined

$$q = W_V/(W_V + W_L) \qquad (9)$$

Eliminating U_{LN}, U_{VN}, A_N, A_{VN}, A_{LN}, and W_V from Equations 4 to 9 then re-arranging, gives finally

$$\frac{1}{C_V'.\beta}\cdot\frac{q}{1-q}\cdot\frac{W_{LN}}{W_{VN}} = \frac{W_{LN}}{W_L} - \frac{1}{C_L'\alpha} \qquad (10)$$

Write the dimensionless parameter

$$\frac{q}{1-q}\cdot\frac{W_{LN}}{W_{VN}} = Y \qquad (11)$$

Then Equation 10 can be written

$$\frac{Y}{C_V'.\beta} = \frac{W_{LN}}{W_L} - \frac{1}{C_L'.\alpha} \qquad (12)$$

In the above equations W_{LN} and W_{VN}, single-phase flows calculated using the two-phase pressure drop can be evaluated by conventional means. It is shown in the appendix that for a sharp-edge orifice

$$\frac{W_{LN}}{W_{VN}} = 1.414\left(\frac{\rho_{LI}}{\rho_{VI}}\right)^{0.5} f(r,n) \qquad (13)$$

where ρ_{LI} and ρ_{VI} are respectively the liquid and vapour densities at the orifice initial pressure, r is the ratio of the final and initial pressures, and n is the vapour expansion index. Where n is 1.3 (the appropriate value is discussed in the next section) approximate equations are

$$f(r, n) = 0.7 + 0.55\,(1-r) \qquad (14)$$

for r values from 1 to 0.8, and

$$f(r, n) = 0.63 + 0.87(1-r) \qquad (15)$$

for r values from 0.8 to zero. The precise form of this function is given in the appendix. The maximum deviation of the precise equation from these approximate equations is ± 3 per cent.

Benjamin and Miller (1) have shown that for sharp-edge orifices the flow of single-phase saturated liquid may be evaluated using the normal "cold water" formula

$$C_L.W_{LN} = C_L \cdot A_N \sqrt{2g\,p_I\,(1-r)\,\rho_{LI}} \qquad (16)$$

where p_1 is the initial pressure, and C_L is the liquid contraction coefficient. C_L, for their tests, can be evaluated approximately using the formula

$$C_L = 0.617 - 0.009 \frac{p_1}{\rho_{L1}}(1-r) \qquad (17)$$

where the pressure is in lb./sq. in. abs. and the density in lb./cu. ft. In considering the form of Equation 16 it should be remembered that WLN is defined as the flow with a contraction coefficient of unity.

Conditions of flow

Previous investigators have observed that during flow of a saturated liquid it may either be in a stable or a metastable state ; a metastable condition is one where the temperature is above the saturation temperature, or conversely the pressure is less than the saturation pressure corresponding to the temperature. Under metastable conditions the change of state of part of the liquid to vapour is delayed. The comparable phenomenon with steam is more generally known as undercooling ; during the expansion of steam from the dry condition, condensation of part of the steam will not immediately occur, and it will expand with its temperature dropping below its normal " stable " temperature. The well-known Wilson line is associated with this phenomenon, though a number of experimenters have shown that a Wilson " Zone " may be a more appropriate name (11) as the point of transition to stable conditions does not correspond to precise conditions of total heat and entropy as implied by the Wilson line, but depends also on the time available for the necessary mass and heat transfers to permit condensation.

It would appear likely that the phenomenon of metastable flow can occur during two-phase flow, and this is partly substantiated by the experimental observations of Stewart and Yarnall (13). They reported that during the flow of boiling water through two orifices in series, " the liquid-vapour mixture attained a supertemperature of 102.4 deg. F., which is the excess of the actual temperature of 315.4 deg. F. over the saturation temperature of 213.0 deg. F."

Throughout the present article, both the liquid and the vapour are assumed to flow in a metastable state. This implies that the dryness fraction remains constant during flow through the orifice. For the vapour, the normal isentropic expansion relationship p/ρ^n = constant is assumed to hold, where $n = 1.3$.

Application of Theoretical Equations

In equation 12 there are four unknowns α, β, C_L', and C_V', hence it cannot be applied directly to the prediction of flow. However, inspection of the equation suggests that the dimensionless parameters $\frac{W_{LN}}{W_L}$ and Y may be used to correlate the available data, as the unknowns are presumably functions of one or other of these parameters. On application of the parameters to the data of Benjamin and Miller (1) a number of different plots were tried before a plot of $\frac{W_{LN}}{W_L} - \frac{1}{C_L}$ to a base of Y was found to give a linear relationship on a log-log plot as shown in Fig. 2. The mean line through the data represents the equation

$$\frac{W_{LN}}{W_L} - \frac{1}{C_L} = 2.1\ Y^{0.825} \qquad (18)$$

TABLE I—DATA OF BENJAMIN AND MILLER
Sharp-Edge Orifice Diam.: 0.247 in. to 0.879 in.

Test Series No.	1	2	3	4	5	6
p_1 lb./sq. in. abs.	145	145	103	103	75	75
p_2	15	85	15	85	15	55
$r = p_2/p_1$	.103	.586	.146	.825	.200	.734
Maximum q	.05	.05	.08	.08	.11	.11
C_L " Measured " (Equation 16)	.591	.598	.621	.653	.610	.616
C_L " Theoretical " (Equation 17)	.596	.607	.603	.614*	.607	.613

* Measured value of C_L used in Fig. 3.

All the data of Benjamin and Miller, which cover the range shown in Table I, lie within ± 10 per cent. of this equation, where the deviations are in the values of W_L, the liquid flow rate during two-phase flow. The liquid contraction coefficients C_L were evaluated using Equation 17, except for test series number 4 (Table I) where the measured value (i.e. from Equation 16) was used due to the relatively large difference between calculated and measured values.

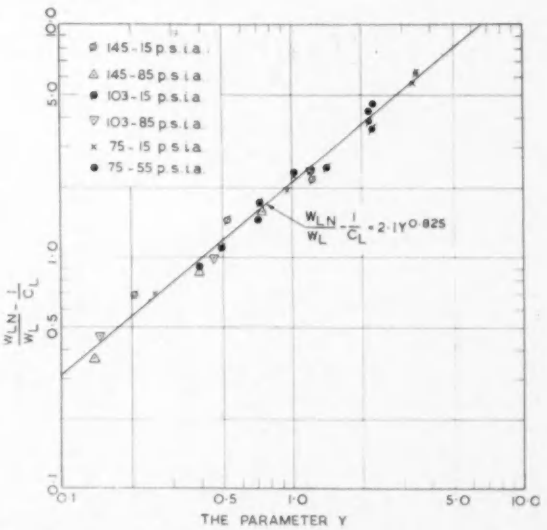


Fig. 2. Correlation of data of Benjamin and Miller. (See Table I.)

Sharp-Edge Orifices in Series

To illustrate the applicability of Equation 18 to the sharp-edge orifice data of investigators other than Benjamin and Miller, it is now compared with the empirical formula of Munro (10) for the flow of saturated water through sharp-edged orifices in series. Munro's formula, which is only applicable with atmospheric back pressure, is

$$\frac{W_L + W_V}{A_N} = \frac{25{,}300\,(p_1-p_2)^{0.8}\,\mu_L^{1.4}}{N^{0.75}\left(\frac{T}{1000}\right)^{2.4}\cdot \rho_{L1}^{1.25}} \qquad (19)$$

where :— N = number of orifices in series
$(W_L + W_V)/A_N$ = mass velocity in lb./sec./sq. ft.
μ_L = initial absolute viscosity of the liquid (lb./hr. ft.)
T = initial absolute temperature (deg. R.)
ρ_{L1} = initial density of the liquid (lb./cub. ft.)

Flow rates calculated by Equation 18 are compared in

Fig. 3 with values obtained by Equation 19 for 2 and 4 orifices in series and the pressure range covered by Munro's data. The maximum deviation of Equation 18 from 19 is − 10 per cent. It is not possible to make comparison with the actual experimental data due to its manner of presentation in the original paper. In applying Equation 18 the quality between successive orifices is evaluated from the estimated pressure and the assumption

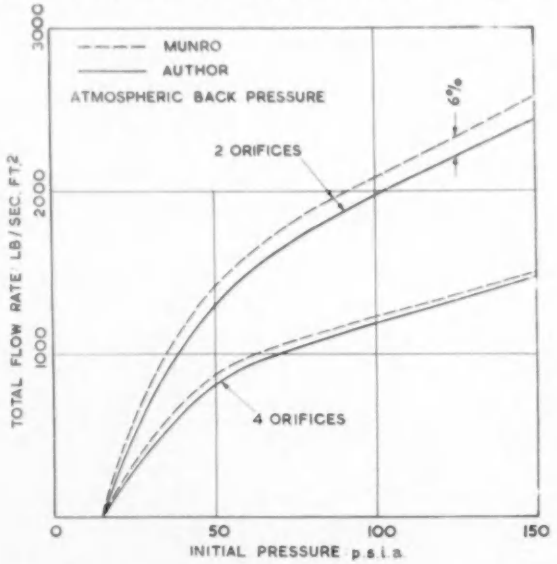


Fig. 3. Comparison between flow rates through orifices in series as predicted by equations of Munro and author respectively.

that the total heat is the same as at the beginning of the expansion (where the quality, or dryness fraction, is zero). A trial and error procedure is necessary to find the flow corresponding to a given overall pressure drop. The value of the liquid contraction coefficient C_L is taken as 0.61 throughout. Table II compares experimental and theoretical values of the pressures between successive orifices.

TABLE II—DATA OF MUNRO
Orifices in Series: Inter-Orifice Pressures
Orifice Diameters: 0.25 in. to 0.625 in.
Pressures lb./sq. in. abs.

No. of Orifices		2	3	4
p_1	Measured	57*	144	82
p_2	Measured	49	133	75
	Calculated	48.5	128	76
p_3	Measured	30	110	67
	Calculated	—	101	67
p_4	Measured	—	30	57
	Calculated	—	—	54
p_5	Measured	—	—	30

* Measured values approximate, as taken from graph.

Numerical example

Determine the flow of a steam-water mixture of initial dryness fraction 0.3 through a 1/2 in. dia. sharp-edge orifice where the initial pressure is 100 lb./sq. in. abs. and the back-pressure is atmospheric.

From Callendar's Tables $\rho_{L1} = 56.2$ lb./ft.^{3} and $\rho_{V1} = 0.225$ lb./ft.^{3} at 100 p.s.i.a.

The pressure ratio is

$$r = 14.7/100 = 0.147$$

The single-phase liquid flow corresponding to the two-phase pressure drop and a unit contraction coefficient is (from Equation 16)

$$W_{LN} = A_N\sqrt{2g \cdot p_1 (1-r) \rho_{L1}}$$

$$= \frac{\pi}{4} \times \frac{0.5^2}{144}\sqrt{2 \times 32.2 \times 100 \times 144 (1-0.147) 56.2}$$

$$= 9.1 \text{ lb./sec.}$$

From Equation 15

$$f(r, n) = 0.63 + 0.87 (1-0.147) = 1.37$$

Therefore from Equation 13

$$\frac{W_{LN}}{W_{VN}} = 1.414 \left(\frac{\rho_{L1}}{\rho_{V1}}\right)^{0.5} f(r, n)$$

$$= 1.412\left(\frac{56.2}{0.225}\right)^{0.5} \times 1.37 = 30.6$$

and from Equation 11

$$Y = \frac{q}{1-q} \frac{W_{LN}}{W_{VN}} = \frac{0.3}{1-0.3} \times 30.6 = 13.1$$

For a sharp-edge orifice C_L is approximately 0.61 ; therefore, Equation 18 becomes on substitution of the above values

$$\frac{9.1}{W_L} - \frac{1}{0.61} = 2.1 (13.1)^{0.825}$$

from which

$$W_L = 0.47 \text{ lb./sec.}$$

The total flow is

$$\frac{W_L}{1-q} = \frac{0.47}{1-0.3} = 0.67 \text{ lb./sec.}$$

Discussion

It can be shown using Equations 12 and 18 that for large Y values unacceptable values of α and β are obtained, consequently Equation 18 will not be applicable where there is a large dryness fraction. It appears likely that it will be applicable up to dryness fractions about 0.5; however, further experimental work is required to confirm this. Further experimental and theoretical work is also required to develop equations applicable to the case where the kinetic energy before the orifice is not negligible (as is the case in the data analysed).

The usefulness of the proposed parameter Y in correlating flow through orifices has been demonstrated. It can be readily shown, as follows, that it will also correlate data for flow of liquid-air mixtures through horizontal tubes, where the total two-phase pressure drop is due to friction. The single-phase liquid flow is here related to the two-phase pressure drop by the normal friction equation

$$\triangle p_{TP} = \frac{\lambda \cdot L \cdot W_{LN}^2}{2g \cdot d \cdot \rho_L \cdot A_t^2} \qquad (20)$$

and where

$$\lambda = a/Re^m \qquad (21)$$

the relationship becomes

$$\triangle p_{TP} = \frac{a \cdot \mu_L^m \cdot L \cdot W_{LN}^{2-m}}{2g \cdot d^{m+1} \cdot \rho_L \cdot A_t^{2-m}} \qquad (22)$$

A similar equation can be written for the gas. Consequently it follows

$$\frac{W_{LN}}{W_{VN}} = \left(\frac{\rho_L}{\rho_V}\right)^{\frac{1}{(2-m)}} \left(\frac{\mu_V}{\mu_L}\right)^{\frac{m}{(2-m)}} \qquad (23)$$

Therefore

$$Y = \frac{q}{1-q} \cdot \frac{W_{LN}}{W_{VN}} = \frac{W_V}{W_L} \cdot \left(\frac{\rho_L}{\rho_V}\right)^{\frac{1}{(2-m)}} \left(\frac{\mu_V}{\mu_L}\right)^{\frac{m}{(2-m)}} \quad (24)$$

In this form the parameter Y is similar to the well-known Lockhart-Martinelli parameter X used to correlate liquid-gas (8) and, in a slightly different form, steam-water flow (9) through pipes. The parameter X is $\sqrt{\triangle p_L / \triangle p_V}$ where $\triangle p_L$ and $\triangle p_V$ are respectively the single-phase pressure drops when the liquid and vapour/gas flow alone. From Equation 22 it follows

$$X = \left(\frac{W_L}{W_V}\right)^{\frac{(2-m)}{2}} \left(\frac{\rho_V}{\rho_L}\right)^{\frac{1}{2}} \left(\frac{\mu_L}{\mu_V}\right)^{\frac{m}{2}} \quad (25)$$

Hence

$$Y = X^{-\frac{2}{2-m}} \quad (26)$$

For smooth tubes, where m is 0.25

$$Y = X^{-\frac{1}{0.875}} \quad (27)$$

The author and a former colleague have shown (4) that for liquid-air mixtures flowing turbulently through smooth tubes at pressures close to atmospheric

$$\frac{\triangle p_{TP}}{\triangle p_L} = 1 + 21/X + 1/X^2 \quad (28)$$

where $\triangle p_{TP}$ is the two-phase pressure drop. In terms of Y this becomes

$$\frac{\triangle p_{TP}}{\triangle p_L} = 1 + 21Y^{0.875} + Y^{1.75} \quad (29)$$

Hence, Y is a parameter applicable to the correlation of liquid-vapour flow through both orifices and pipes ; the Martinelli parameter does not give a satisfactory correlation when applied to orifices.

Summary and conclusions

The equation

$$\frac{W_{LN}}{W_L} - \frac{1}{C_L} = 2.1\, Y^{0.825}$$

where Y is

$$Y = \frac{q}{1-q} \cdot \frac{W_{LN}}{W_{VN}}$$

has been shown to predict flow rates within ± 10 per cent. of the experimental values for flow through sharp-edge orifices. The above equation also gives flow rates with a maximum deviation of – 10 per cent. from the values predicted by the empirical equations of Munro for flow through a number of orifices in series. Good agreement is obtained for pressures between successive orifices. Further experimental data are required to determine the range of dryness fraction for which the equations are applicable. The available results cover a range up to a dryness fraction of 0.11.

The proposed parameter Y may prove of use in correlating two-phase flow friction data for tubes.

APPENDIX

Single-phase mass flows

For the flow of a vapour (6) the velocity at the vena contracta is

$$U_{VN} = \sqrt{\frac{g p_1}{\rho_{V1}} \cdot \frac{2n}{n-1} \cdot \left(1 - r^{\frac{n-1}{n}}\right)} \quad (30)$$

where p_1 is the initial pressure, ρ_{V1} the initial density, and n the index in the isentropic expansion relationship

$$p/\rho^n = Constant \quad (31)$$

Equation 31 gives the density at the throat as

$$\rho_V = \rho_{V1}\, r^{1/n} \quad (32)$$

Hence combining Equations 7, 30, and 32

$$W_{VN} = A_N \sqrt{g \cdot p_1 \cdot \rho_{V1} \cdot r^{2/n} \cdot \frac{2n}{n-1}\left(1 - r^{\frac{n-1}{n}}\right)} \quad (33)$$

With the flow of a compressible fluid a critical pressure will occur at $r = r_C$ where

$$r_C = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}} \quad (34)$$

Hence, for back pressures at or below critical, from Equations 33 and 34

$$W_{VN} = A_N \sqrt{g \cdot p_1 \cdot \rho_{V1} \cdot n \cdot \left(\frac{2}{n+1}\right)^{\frac{n+1}{n-1}}} \quad (35)$$

For sharp-edge orifices with back pressures at and above the critical pressure, from Equations 16 and 33

$$\frac{W_{LN}}{W_{VN}} = 1.414 \left(\frac{\rho_{L1}}{\rho_{V1}}\right)^{1/2} \left\{\frac{1-r}{r^{2/n}\left(1 - r^{\frac{n-1}{n}}\right)} \cdot \frac{n-1}{2n}\right\}^{1/2} \quad (36)$$

and with back pressures at and below critical pressure, from Equations 16 and 35,

$$\frac{W_{LN}}{W_{VN}} = 1.414 \left(\frac{\rho_{L1}}{\rho_{V1}}\right)^{1/2} \cdot \left(\frac{1-r}{n}\right)^{1/2} \cdot \left(\frac{n+1}{2}\right)^{\frac{n+1}{2(n-1)}} \quad (37)$$

Both these equations can be written

$$\frac{W_{LN}}{W_{VN}} = 1.412 \left(\frac{\rho_{L1}}{\rho_{V1}}\right)^{1/2} f(r, n) \quad (38)$$

where f(r, n) for n = 1.3 is given by Equations 14 and 15.

Symbols

A_L	Liquid cross-section at vena contracta during two-phase flow
A_{LN}	Liquid cross-section at throat during two-phase flow
A_V	Vapour cross-section at vena contracta during two-phase flow
A_{VN}	Vapour cross-section at throat during two-phase flow
A_N	Orifice throat cross-section
A_t	Tube cross-section
a	Constant in Equation 21
C_L	Liquid contraction coefficient
C_L'	Ratio of liquid cross-section at vena contracta to that at throat during two-phase flow, i.e. A_L/A_{LN}
C_V'	As above for vapour, i.e. A_V/A_{VN}
D	Tube diam.
g	Gravitational acceleration
L	Pipe length
m	Index in Equation 21
n	Index of isentropic expansion in Equation 31
$\triangle p_{TP}$	Pressure drop during two-phase flow
$\triangle p_L$	Pressure drop where liquid phase flows alone
$\triangle p_V$	Pressure drop where vapour phase flows alone
p_1	Initial pressure (i.e. pressure before orifice)
p_2	Back pressure (i.e. pressure after orifice)
q	Dryness fraction, i.e. $W_V/(W_V + W_L)$
R_e	Reynolds number
r	Ratio of back-pressure to initial pressure, i.e. p_2/p_1
r_c	Critical pressure ratio
T	Temperature
U_{LN}	Single-phase liquid velocity at vena contracta corresponding to two-phase pressure drop

U_L	Liquid velocity at vena contracta during two-phase flow
U_{VN}	Single-phase vapour velocity at vena contracta corresponding to two-phase pressure drop
U_V	Vapour velocity at vena contracta during two-phase flow
W_L	Liquid weight flow rate during two-phase flow
W_{LN}	Liquid weight flow rate during single-phase flow with unit contraction coefficient and two-phase pressure drop
W_V	Vapour weight flow rate during two-phase flow
W_{VN}	Vapour weight flow rate during single-phase flow with unit contraction coefficient and two-phase pressure drop
X	Lockhart-Martinelli parameter, i.e. $\sqrt{\triangle p_L / \triangle p_V}$
Y	Proposed parameter, i.e. $\frac{q}{1-q} \frac{W_{LN}}{W_{VN}}$
α	Velocity ratio U_L/U_{LN}
β	Velocity ratio U_V/U_{VN}
λ	Friction factor in Equation 20
μ_L	Liquid viscosity
μ_V	Vapour viscosity
ρ_{LI}	Liquid density before orifice—weight per unit volume
ρ_L	Liquid density at vena contracta—weight per unit volume
ρ_{VI}	Vapour density before orifice—weight per unit volume
ρ_V	Vapour density at vena contracta—weight per unit volume

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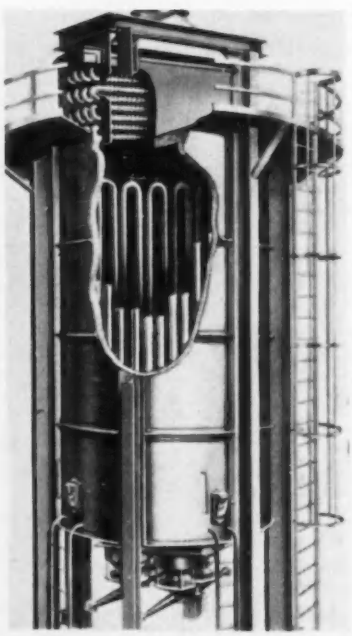
ELEVATED HEATING TEMPERATURES

The elevated heating temperatures now required by industry have created a demand for new and improved methods and equipment, and it is, therefore, of interest to note that Newton Chambers & Co. Ltd., Thorncliffe, near Sheffield, have entered into a licence agreement with Struthers Wells Corporation, of Warren, Pennsylvania, U.S.A., for the manufacture and sale in the United Kingdom of Struthers Wells equipment designed for a wide range of high-temperature heating applications, and which comprises a complete range of fired heaters for operation in connection with circulating heating systems of the Dowtherm type, in addition to those for the direct heating of process materials. High-temperature heating is generally considered as being in a temperature range above that of the normal steam boiler pressures. For example, temperatures of 700 deg. F. to 750 deg. F. can be obtained using Dowtherm. With this material, pressures in the circulating system, heat exchangers, etc., rarely exceed about 80 lb./sq. in., and at these low-pressures the thickness of heat-exchanger tubes, tube-plates and shells, and consequently the overall installation costs are kept at reasonable levels. Several methods are available for obtaining these elevated temperatures. Process fluids including gas, steam, air, oils, asphalt and organic chemicals may be continuously heated in direct-fired units, while indirect heating of process equipment may be carried out by the use of fired heaters in connection with the circulation of thermally stable fluids. These fluids include Dowtherm, in the case of which heat transfer can take place either in the liquid or vapour phase ; hydro-carbon oils of special types ; Paracymene ; Aroclor ; and high-temperature salt such as potassium sodium alloy. Special equipment such as electrically heated units is also available. The heating units are available in various sizes, from a small pilot plant to large commercial units, and where possible the equipment is completely shop-assembled and dispatched ready for installation. Larger units, however, are assembled on site, but this can be undertaken with a minimum of labour due to the sectionalised method of construction used, and the fact that the equipment is of simplified design. Complete automatically-controlled heating systems, including instruments, safety devices, piping and other accessories are available, or alternatively the heater may be supplied as a separate unit.

The fired heaters are designed and constructed in several standard types, and the type best suited to a given service may depend on a number of factors including size of equipment, type of fuel available, thermal efficiency desired, the temperature range of heating the thermal sensitivity of the heated material etc. The type most commonly used in the Struthers Wells systems is the vertical type in which heat transfer is predominantly by radiation. For maximum thermal efficiency a bank of heating tubes of the extended surface type is commonly superimposed on the vertical radiation type heater to recover the heat contained in the waste products of combustion by convective means.



Section through a Struther Wells direct-fired heater, which is now, under licence agreement, being made in the U.K. by Newton Chambers & Co Ltd., Thorncliffe, Nr. Sheffield.

200-MW Turbo-Alternators for Canada

THE Hydro Electric Power Commission of Ontario, Canada, have ordered from C. A. Parsons & Co. Ltd. four 200-MW turbo-alternator sets to be installed in the Richard L. Hearn power station, Toronto. With this additional plant the station will have an installed capacity of 1,200-MW, making it the largest station in the world with machines made by one manufacturer. The first Parsons turbines to be installed there were commissioned during the years 1951-53, the plant comprising four two-cylinder machines, running at 1,800 r.p.m., and each driving a 100-MW hydrogen-cooled, three-phase generator. Each set has its own steam generator and auxiliary plant, steam conditions at the turbine stop valve being 850 lb./sq. in. and 900 deg. F.

The 200-MW sets, the first of which has already been delivered to the station, will be of the cross-compound design, one line consisting of an h.p. turbine and a double-flow i.p. turbine driving a 100-MW generator at 3,600 r.p.m., while the second line will consist of an i.p. turbine and a double flow l.p. turbine, also driving a 100-MW generator, but at 1,800 r.p.m.

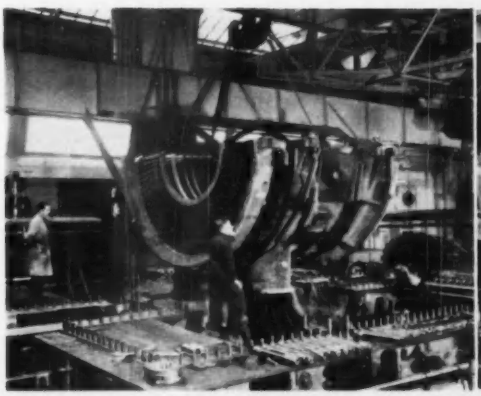
The units are designed to operate with steam at a pressure of 1,800 lb./sq. in. and a temperature of 1,000 deg. F., with reheat between the h.p. cylinder and the first i.p. cylinder to a temperature of 1,000 deg. F. Steam from the steam chests is admitted to the h.p. turbine at the end nearest the generator and passes from the exhaust of this cylinder to the reheater. It is then led to the centre of the first i.p. turbine and flows outward to the ends, from which it is passed to the second i.p. turbine which is on the 1,800 r.p.m. line. From this cylinder the steam is exhausted through twin overhead pipes into a double flow l.p. turbine, and thence through the two exhausts into the condenser.

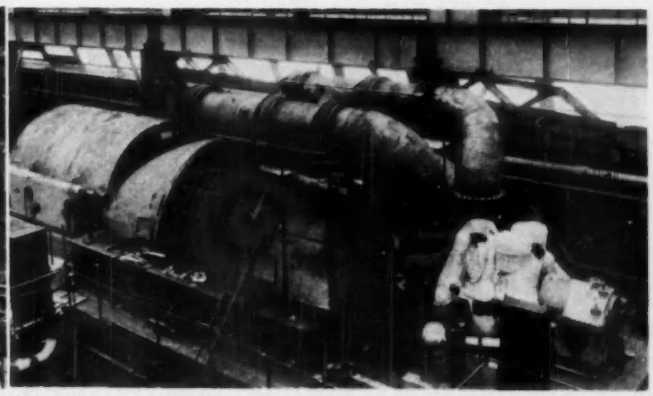
The h.p. cylinder is of the double-shell design, arranged so that the outer surface of the inner cylinder is continuously washed with a flow of steam adequate to maintain a reasonably uniform temperature across the cylinder wall. The material used in the manufacture of the inner and outer cylinders is chrome-molybdenum-vanadium steel. Inside the inner cylinder are located separate nozzle blocks which take the full steam pressure and temperature. This arrangement assures minimum distortion due to temperature variation, and helps to eliminate thermal gradients during starting, stopping and loading. The first i.p. cylinder is also of double-shell design, the outer casing being fabricated of carbon-molybdenum steel and the inner of chrome-molybdenum-vanadium steel. The second i.p. cylinder is of single-shell construction, the material used being carbon steel.

The l.p. cylinder is of a very rigid construction which consists of an outer fabricated shell and an inner cast steel blade carrier. The outer shell, in which are located the low-pressure spindle bearings and which consequently carries the considerable weight of this spindle, consists of three massive sections. Fig. 1 shows the bladed inner cylinder of the first machine being lowered into position during erection, at the Parsons' Heaton works.

The h.p. turbine shaft is of solid construction, the material used again being chrome-molybdenum-vanadium steel. The shaft for the first i.p. turbine is also a solid construction and is made from the same material as the h.p. shaft. A hollow forged drum, integral with the shaft at one end and closed at the outer by a flanged forging which is extended to form the other end of the shaft, is the form of construction used for the second i.p. turbine shaft. The walls of the drum are comparable in thickness with the metal of the surrounding cylinder, so that both cylinder and shaft respond to temperature changes at approximately the same rate. The l.p. turbine shaft which is not subjected to wide temperature variations, but has a high rotational stress, is built up of discs of nickel-chrome steel shrunk on to a carbon steel shaft.

The blading in the h.p. turbine comprises a two-row impulse wheel followed by ten stages of reaction blading ; these blades are machined from the solid with shroud and root integral with the blade. This type of reaction blading is also used throughout the first i.p. turbine. An improved form of blade sealing is incorporated in the h.p. turbine ; no thrust adjustment is needed. The last





(Left) Fig. 1. The bladed inner cylinder of the first of four 200-MW cross-compound sets for the Richard L. Hearn station being lowered into position during erection at the Heaton Works of C. A. Parsons & Co. Ltd. (Right) Fig. 2. The i.p.-l.p. line nearing completion.

row blades at each end of the l.p. cylinder are cast into cast-iron frames, these frames being located in the centre section of the cylinder with the rest of the blading. The last row blades of the l.p. shaft are secured by means of a "fir-tree" root broached axially. To prevent water erosion on the last rows of moving blades, tungsten steel shields are brazed along the leading edge of each blade. Segmental, spring-backed glands are employed throughout the turbine, the packing steam supply being fully automatically controlled. Fig. 3 shows the h.p.-i.p. line with the turbine cylinder covers removed, and Fig. 2, the i.p.-l.p. line nearing completion for testing at the Heaton works.

Two steam chests are employed, one on each side of the h.p. turbine, each being of forged construction. Each chest contains a combined stop and emergency valve and two governor valves. To prevent the steam stored in the reheater from flowing into the turbine when sudden loss of load occurs, intercepting valves are fitted in the steam lines between the reheater and the first i.p. cylinder. Reheat emergency stop valves are also provided as a safeguard against possibility of faulty operation of the intercepting valves. In addition, release valves simultaneously release the steam to the atmosphere.

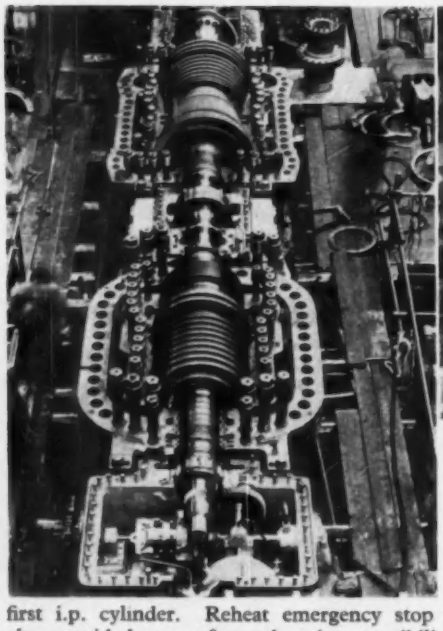
The turbine has two governors, the main speed control governor, housed in the h.p. cylinder steam-end pedestal, and an auxiliary governor housed in the second i.p. cylinder steam-end pedestal. Each is mounted on a cross-shaft driven by a worm and wheel from the turbine shaft. Both governors operate the governor valves, intercepting and release valves by varying the oil pressure of a common pilot oil system. Also housed in the h.p. cylinder pedestal is the main oil pump which is of the centrifugal-type, driven through a helical pinion and wheel. Further controls in the turbine system are: a vacuum operated unloading gear, vacuum trip switch, an unloading gear which operates on low boiler pressure, a load limiting gear and an anti-motoring device. Motor driven turning gear is provided on each line to ensure uniform cooling and heating of the turbine shafts when shutting down or starting up the machine.

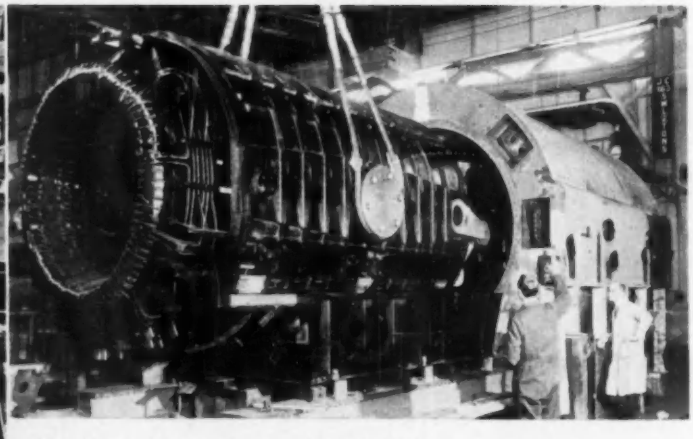
Hydrogen cooled generators

Each generator has a maximum rating of 100-MW at 13,800-V, 0.85 p.f. The h.p. line generator is driven at 3,600 r.p.m., and the l.p. line generator, which has a four-pole field system, is driven at 1,800 r.p.m. To facilitate transport, the stator for the low-speed generator is manufactured in two parts. The inner section, comprising frame, core, and windings, weighs 100-tons, while the outer section, comprising the outer casing and gas coolers, weighs 63 tons.

Both inner and outer casings are fabricated from mild steel plate, the outer casing being sub-divided by annular plates which form ducts for the ventilating system and housing for the gas coolers. The core is built up from laminations of high grade silicon steel, which are insulated on both sides with stoved enamel. The stator for the high speed generator is of single piece construction having a total weight of 135-tons. Each stator winding is of the basket or diamond coil type, the core conductors being formed from a number of copper strips of small cross-section, each strip being insulated with impregnated glass tape. The portion of the conductors lying in the stator slots is insulated with a flexible micanite tube; this has the advantage of permitting relative expansion of the conductor and stator core. After the stators have been wound and insulated, they are dried under vacuum and the end windings impregnated under vacuum and pressure.

The rotors for both generators are machined from single forgings of chrome-molybdenum-steel; radial slots milled in the body and insulated with troughs of epoxy-resin glass-fibre laminate receive the windings which are of silver bearing copper strip. Cooling of the rotors is effected by means of sub-slots machined below the normal winding slots and fed at each end with hydrogen. Radial slots are provided at regular intervals





(Left) Fig. 3. The h.p.-i.p. line of the 200-MW turbine, with the cylinder covers removed.

(Above) Fig. 4. The low-speed generator stator being assembled at the Heaton works of C. A. Parsons & Co. Ltd.

along the coil length, providing ventilating passages through the coil and exhausting into the air gap. The hydrogen comes into direct contact with the copper, removing the heat direct.

The hydrogen system associated with each generator is operated as an independent unit, controlled by its own hydrogen cubicle, which contains all the valves and instruments necessary for the normal operation of the generator. These controls include measurement of the gas pressure and temperature which are automatically maintained, and of the gas purity which is usually adjusted at about 96 per cent. The hydrogen is prevented from escaping through the annulus around the rotor shaft, by special oil-seals mounted between the stator end-covers and the bearing pedestals. The seals are of the thrust type, oil being supplied to them direct from the power oil system. The small amount of oil which passes to the hydrogen side of the seals is led to a detraining tank, where the entrained hydrogen is liberated.

The excitation for each generator is supplied from electric motor-driven exciters. Stability of excitation is assured by supplying the fields of the main exciters from pilot exciters, both main and pilot armatures being mounted on the same shaft. Ventilation of the exciters is provided by means of blowers mounted on the outboard ends of the armature shafts.

A Mechanised Coal Depot

A MECHANISED coal-handling plant at the Palace Gates, Wood Green, London depot of Charrington, Gardner, Locket & Co. Ltd., was formally opened by Sir Brian Robertson, chairman of the British Transport Commission, on July 15th, 1958. This installation is the first of its kind in the country, and has been designed specifically to speed coal deliveries to domestic consumers in a wide area of North London. It will, in fact, do the work previously undertaken by eight depots. The plant was designed and engineered by Charrold Ltd., and provides for the handling of three trains a week, each consisting of eighteen 21-ton hopper-bottomed wagons.

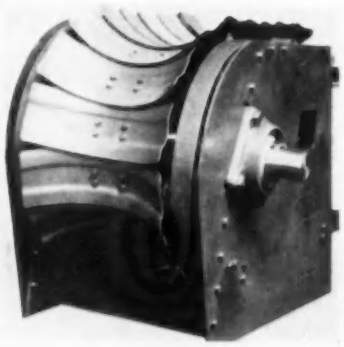
Once the wagons have been delivered to the depot sidings, all movement is taken over by the company's staff. There are three sidings at Palace Gates, two of 600-ft. length and one of 450-ft. length, and a powered winch is available for moving either half of the train, and any wagon can be positioned exactly as required. The coal discharged from the wagons is received in a small hopper located beneath the rails, and transferred on to an elevating conveyor, the feed being controlled

The elevating conveyor at the Palace Gates depot, transferring coal from the rail hopper to the screening unit.

by a reciprocating feeder to a rate well within the capacity of the conveyor. The elevating conveyor which can handle 120 ton/hr. of coal, is of the articulated steel pan type, 127-ft. long at an angle of 30°, its vertical height being 50-ft. from the bottom of the rail hopper pit to the top of the conveyor. The coal discharged from the conveyor is passed over a screening unit for the removal of any smalls made in transit, and then to a shuttle conveyor for distribution to any one of a bank of twelve 20-ton capacity hoppers which are fitted with rubber-lined anti-breakage devices. Both the screening unit and the shuttle conveyor were supplied by Niagara Screens Ltd.

The hoppers all terminate in a sack-filling feeder at the lorry-loading bay where the aim is to present an accurately weighed sack at a height convenient for loading. The main staging is at lorry floor level, and the sack is filled at a height from which it is easily lifted and carried on to the vehicle. The sack filling and weighing arrangements incorporate in their design a feeder device that guarantees a consistent flow of coal of any size up to an 8-in. cube. Coal is brought forward by the application of pressure on a footswitch, and a correct weighing made by reference to an indicating pointer on an adjacent scale. Storage bays formed from Stelcon free-standing units, and with a capacity of 6,000 tons, are provided on the site. When coal is required to be put into stock, the shuttle conveyor is traversed beyond the end of the hopper bank and the coal discharged on to a chute terminating at ground level, where a mobile shovel transports it to the appropriate storage bay.

The technical problems involved in handling coal are, of course, linked with its friable nature, the wide variations in coal sizes and the irregular shape of the material. The Palace Gates plant has been designed with these problems in mind, and its success can be judged from the fact that the coal is transported gently, at a uniform rate of flow, irrespective of size variations, and is delivered with as little damage as possible at the lorry-loading bay. The equipment employed has contributed greatly to these factors, and of particular interest is the elevating conveyor, supplied by Wharton Engineers (Elstree) Ltd., and which consists of head and tail units joined together by two sets of rails, one carrying the loaded belt and the other the empty return belt. The conveyor belt itself is made up of a series of overlapping curved steel pans attached, each to the other, by a centrally positioned steel linked driving chain, located below rail level. At regular intervals brackets are attached to the pans, to which are bolted spindles carrying the necessary rollers. A feature of the design is the curved pan, the curvature together with the centrally located driving chain ensuring a mated surface to the overlapping faces of the pans and per-



(Left). The head unit of the conveyor showing the action of the pans at the off-loading point.

(Right). A typical section of the curved-pan conveyor showing overlapping pans, the rollers and support bridges.

mitting curving of the conveyor in both horizontal and vertical planes. Close contact of the overlapping faces is maintained by reason of the centre line of the driving chain being below that of the carrying rollers, thus the tension of the chain holds the pans in close contact at all times preventing spillage of even the finest materials. When operating round bends in the horizontal plane, swivel links are fitted at intervals to the driving chain. The fact that the rollers move with the pans results in the provision of a steady platform for the material being carried, and when elevating, the conveyor belt is held to a short radius by means of guard rails holding the rollers to the track rails, thereby reducing appreciably the length of floor space required for any given elevating requirement. Being of steel construction, the conveyor belt can also handle hot materials with on-loading heats of up to 750 deg. C.

The head unit is constructed of steel plate having a heavy cross-member of box formation. The driving sprocket is made up of three segments which are bolted on tapered stud and nut faces to a steel hub, which in turn is keyed to an alloy-steel shaft mounted on plummer block bearings. The idler sprocket in the tail unit is of similar design, but the plummer blocks are mounted in slides to allow for adjustment of the chain tension. The power train associated with the conveyor at Palace Gates comprises a 15-h.p. electric motor, supplied by Higgs Motors Ltd., driving through a Vulcan-Sinclair fluid-coupling supplied by Fluidrive Engineering Co. Ltd., and through a Holroyd gear-box.

C.E.G.B. PROJECT GROUPS

The Central Electricity Generating Board announces the following appointments to the three Engineering Project Offices which the Board decided to establish to undertake construction work of power stations, including nuclear, and associated sub-stations :—

SOUTHERN PROJECT GROUP

Assistant Chief Project Engineers :—**Mr. W. B. Shannon,** M.Inst.C.E., M.I.Mech.E., M.I.E.E., C.G.I.A. [former chief generation engineer (construction), London Division], and **Mr. W. H. C. Pilling,** B.A.(Hons.), M.I.E.E. (former nuclear project engineer, Headquarters). Project Engineers :— **Mr. J. Irlam,** Associate I.E.E. [former chief generation engineer (construction), South Western Division] ; **Mr. J. Y. Hutchinson,** B.Sc.(Eng.), A.M.I.E.E. [former generation engineer (construction), London Division] ; **Mr. J. H. Osborn,** B.Sc.(Eng.), A.M.Inst.C.E., A.M.I.Mech.E., A.M.I.E.E. [former generation engineer (construction), London Division] ; **Mr. W. H. Sanderson,** A.M.I.Mech.E., A.M.C.T. (former project engineer, Nuclear Power Branch, Headquarters) ; **Mr. E. T. K. Greenham,** A.M.I.Mech.E. [former mechanical engineer (construction), London Division] ; **Mr. H. B. Campbell,** A.M.I.Mech.E., M.Inst.F. [former generation engineer (construction), Eastern Division] ; **Mr. D. A. Pask,** A.C.G.I., B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E., M.Inst.F. (former project engineer, Nuclear Power Branch, Headquarters) ; and **Mr. H. Gleave,** A.M.I.Mech.E., A.M.I.Struct.E., Associate I.E.E., M.Inst.F. [former generation engineer (construction), London Division]. Programmes and Progress Engineer : **Mr. P. M. Blake,** B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E. (former personal technical assistant to chief engineer, Headquarters). Administrative Officer : **Mr. J. C. Ivison,** A.I.M.T.A. (former senior assistant accountant, Eastern Division).

NORTHERN PROJECT GROUP

Assistant Chief Project Engineers :— **Mr. C. R. Watson Smyth,** M.Inst.F. [former chief generation engineer (construction), North West, Merseyside and North Wales Region], and **Mr. B. C. Pyle,** M.I.E.E. [former chief generation engineer (construction), Southern Division]. Project Engineers :— **Mr. H. G. B. Mahon** [former chief generation engineer (construction), North Eastern Division] ; **Mr. A. J. Hodgkinson,** A.M.I.Mech.E., A.M.I.Struct.E., Associate I.E.E. [former generation engineer (construction), Yorkshire Division] ; **Mr. A. N. Duffett,** B.Eng., A.M.I.E.E., A.M.I.Mech.E., A.M.Inst.F. [former generation engineer (construction), North West, Merseyside and North Wales Region] ; **Mr. K. B. Harrison,** A.M.C.T., A.M.I.Mech.E. [former generation engineer (construction), North West, Merseyside and North Wales Region] ; **Mr. J. Shepherd** [former generation engineer (construction), North West, Merseyside and North Wales Region] ; and **Mr. C. E. Pugh,** A.M.I.Mech.E., A.M.Inst.F. [former generation engineer (construction), North West, Merseyside and North Wales Region]. Programmes and Progress Engineer : **Mr. T. J. Wilkinson,** B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.E.E. [senior assistant engineer (construction), Southern Division]. Administrative Officer : **Mr. N. Wells,** A.C.I.S. (former senior assistant accountant, North West, Merseyside and North Wales Region).

MIDLANDS PROJECT GROUP

Assistant Chief Project Engineers :— **Mr. F. Barrell,** M.I.Mech.E., M.I.E.E., A.M.B.I.M. (former generation station construction engineer, Headquarters), and **Mr. L. C. L. Dale,** M.Sc., A.M.I.E.E. [former generation engineer (construction), Midlands Division]. Project Engineers :— **Mr. E. C. Shackleton,** Associate I.Mech.E., Associate I.E.E. [former generation engineer (construction), South Wales Division] ; **Mr. A. E. Farmer,** M.Sc., M.I.Mech.E., M.I.E.E. [former generation engineer (construction), Midlands Division] ; **Mr. F. Favell,** M.I.Mech.E., M.I.E.E. [former chief generation engineer (construction), East Midlands Division] ; **Mr. R. G. Millard,** A.M.I.Mech.E., A.M.I.E.E. [former generation engineer (construction), East Midlands Division] ; and **Mr. A. H. Jones,** M.I.Mech.E. [former generation engineer (construction), East Midlands Division]. Programmes and Progress Engineer : **Mr. D. C. Bentley,** B.Sc.(Eng.), Grad.I.Mech.E. [former senior assistant engineer generation (construction), South Wales Division]. Administrative Officer : **Mr. H. J. Bick,** M.B.E., A.C.I.S., A.M.B.I.M. (former deputy secretary, Midlands Division).

British Coal Utilisation Research Association

THE annual report of the British Coal Utilisation Research Association, recently published, contains extensive information relating to the Association and its activities during the year ended December 31st, 1957, including a detailed review of the research programmes carried out, abstracts of reports, publications, and patents, and, finally, the accounts for the year.

Referring particularly to the firing of industrial boilers, the report states that a number of lectures on aspects of boiler firing and on means for preventing the emission of grit, dust and smoke have been given, while the results of an extensive series of tests on the coking stoker referred to in the previous year's report have now been published. The 1956 report also mentioned tests being made on a chain-grate stoker incorporating a modified air distribution system, and after a number of experiments, carried out during the year under review, with coals differing in rank, it was found that although the combustion characteristics of the appliances, as shown by the CO_2 content of the flue gases, had been improved, the carry-over into the boiler passes was greater than normal. However, there appeared to be no increase in the dust burden from the exit gases. A new method of controlling the air distribution through the fuel bed of a chain-grate stoker has now been evolved as a result of experiments with a cold air model, and a stoker incorporating the most favourable modifications is now under test in the Association's Economic boiler. Other experiments have shown that, with some designs of chain-grate stoker, a substantial quantity of combustion air, occasionally as much as 30 per cent. of the total supply, may leak into the furnace tube through the end of the stoker. The air does not pass through the fuel bed and can be considered only partially effective as secondary air. It would be better used if injected at such a point as to enable it to mix immediately with combustible gases present in the furnace tube. Ways to minimise this air leakage are being sought.

A simple air/fuel ratio controller, based upon the use of a heated bi-metallic strip, has been further developed. Initial problems, such as the vibration of the element and the adjustment of the zero point, have been solved and the controller's operating characteristics have been determined. Tests to establish its performance and reliability under a range of firing conditions are in hand.

In the field of grit and dust emission, attention has been given mainly to the formulation of procedures, and to the design of equipment for assessing grit and dust emission. A paper dealing with the means for reducing pollution from industrial boilers was contributed to the Conference on Clean Air, organised by the Institution of Mechanical Engineers, and the results of basic research on dust sampling at anisokinetic rates have also been published. Towards the end of the year, the Advisory Committee on Particle Mechanics recommended that the experience gained should be made available nationally by the preparation of a handbook, in which three procedures for determining dust emission are to be specified :—(1) subject to certain provisos that can now be stated explicitly, a single-point sample can be taken with a precision usually of $\pm$ 20 per cent. ; the test will usually suffice to show, for example, whether or not a given plant is responsible for a local nuisance ; (2) for monitoring emission at successive intervals of time, single-point sampling may be adopted under somewhat less restrictive conditions than in (1) ; (3) for accurate estimation of emission, a multi-point sampling procedure must be adopted. These three sampling procedures have been developed from tests on industrial coal-burning plant, etc., and the experience gained has enabled the sampling equipment, based on that described in the annual reports for 1955 and 1956, to be improved. The outcome is to be described in detail in the handbook, which will be issued later this year. The automatic particle counter and sizer developed by the Association in collaboration with a member firm is now in commercial production, and has been subjected to extensive laboratory tests.

Experimental work with a model furnace-tube plant has continued during the year in connection with the heat transfer in shell boilers. Several surveys have been made of the temperature conditions along the length of the furnace tube and have indicated substantial stratification in the gas streams. This confirms the results of an earlier investigation, carried out with the Economic boiler, in which gas samples were taken down the length of the furnace tube. The substantial leakage of air which it has been shown can occur through the rear of a chain grate could account for much of this irregularity in gas temperature. The results, together with the measurements of heat transmission to the furnace tube, have enabled an overall heat balance to be drawn up ; after considerable refinement of measuring techniques, the unaccounted heat loss has been reduced to about 2 or 3 per cent. Modifications have also been made during the year to the Economic boiler in the form of access tubes inserted from the outer shell of the boiler through the steam and water space to the furnace tube. It is now possible to make measurements of the gas in the furnace tube at six points along its length. A small heat flow meter has been developed for measurement of the pattern of heat transmission.

In recent years an increasing number of instances have been brought to the notice of the Association of the build-up of deposits on the rear tube-plate and in the smoke tubes of coal-fired Economic boilers, and during the year a number of case histories of such deposits have been examined and, whilst the investigation is still at an early stage, certain conclusions have been drawn. For example, it has been found that the presence of a deposit usually, but not always, coincides with the use of a coal with a chlorine content in excess of 0.4 per cent. The available case histories show that the trouble is not associated with any particular design of boiler or grate.

The problem of steam wetness has not been the subject of a great deal of research since an improved steam separator was designed some two years ago. Several

successful installations have been carried out, including one on a packaged-type boiler supplying back-pressure steam engines. The number of enquiries from steam users for such separators has increased, and it is hoped during the coming year to arrange for their manufacture.

Deposits and corrosion in water-tube boilers

The main findings of the work in connection with the problem of deposits and corrosion in water-tube boilers carried out during 1957 are summarised under the headings—corrosion of air-heater and other cold end surfaces ; pilot-scale work at Leatherhead ; laboratory studies on the release of chlorine, alkalis and sulphur during the combustion of coal ; and development of instruments.

In the first instance, most of the field work undertaken has been devoted to investigating various means of alleviating the trouble, which occurs with both oil-fired and coal-fired boilers. At Nantes-Chevire power station (Electricité de France) tests were carried out to evaluate the behaviour of dolomite, and ammonia as corrosion-inhibiting additives on oil-fired boilers. Dolomite, injected into the furnace in the proportion of four parts of dolomite per 1,000 parts of oil, effected a small but significant reduction in the acid dewpoint. Further additions of dolomite at the inlet to the air-heater effected no improvement ; larger additions to the furnace were found to be undesirable on account of slagging. Ammonia, added at the rate of 0.6 parts per 1,000 of oil, completely suppressed the acid dewpoint but gave rise to sticky air-heater deposits which themselves were corrosive and which caused rapid blockage of the air-heater. At Wallasey power station, tests were carried out with new burners designed with special air-inlet arrangements. These burners did not affect the acid conditions in the boiler, and made excessive smoke ; they are being modified, however, and further tests are likely to be undertaken. Ammonia injection was also studied at this station, and at an input rate of 0.3 parts per 1,000 parts of oil, the acid dewpoint of 300 deg. F. was suppressed to a water dewpoint (*circa* 140 deg. F.). With a view to assessing the importance of hot iron surfaces in catalysing the reaction $2SO_2 + O_2 \rightarrow 2SO_3$, a special test section has been added to a stoker-fired boiler at Barking power station. Gases tapped off from the superheater chamber are divided into two parallel streams. One stream passes directly to a cooling section containing comparatively little metal surface, and thence to an air-cooled section in which the amount of corrosion taking place is studied, while for comparison, the other stream passes over a considerable area of hot metal before entry to a cooling section, parallel with the first. No significant results have yet been obtained as the installation has been in use for a comparatively short time only and operational difficulties have yet to be overcome. Experiments on a laboratory scale showed only a temporary catalytic effect but, if the current work shows that the effect is an important one, experiments will be continued to find means of suppressing the action, e.g. by the use of coatings on the hot iron surfaces.

At Leatherhead, the large combustor (P.F.4) which burns up to 50 lb./hr. of pulverised coal, has been used to study the effect of gas velocity on the quantity and strength of alkali-bonded deposits. It has been found that with an increase in gas velocity the quantity of bonded material increased apparently to a maximum ; thereafter both the strength of the bonding and the amount of the deposit are reduced. Up to the maximum gas velocity of about 50 ft./sec., the amount of deposit is a function of the increase in gas velocity and, insofar as it can be measured, the tightness of bonding follows a similar trend. This suggests that the flow pattern, as well as the average velocity, of gases through the superheater chamber and over the tubes may be of importance in determining whether a given boiler will be subject to superheater fouling. It was also found that with the coal used (Thoresby Slack), the deposits from a low (12 per cent.) ash sample were more strongly bonded and greater in quantity than from a high (18 per cent.) ash sample, at the same heat release rate.

Laboratory studies on the mode of release of chlorine, alkalis and sulphur during the combustion of coal over the temperature range 200-930 deg. C., were discussed in the 1956 annual report. This work, in which the coals were heated slowly (at approximately 9 deg. C./min.), has now been extended to cover temperatures up to 1,500 deg. C. under shock heating conditions. Some of the analytical difficulties arising at the higher temperatures have not yet been overcome, but the results confirm that, as with slowly-heated coal, all the chlorine is released by 750 deg. C., whilst up to 930 deg. C. 20 per cent. of the sulphur is retained in the residue. Up to 930 deg. C. no sodium or potassium was lost by the low or medium chlorine coals, but with the high chlorine coal (0.9 per cent.) 30 per cent. of the sodium was lost by the time this temperature was reached. To obtain related information for pulverised coal, the use of a small combustor (P.F.5-120 g./hr.) is providing promising results. On this small scale, difficulty in sampling the gas stream of a larger unit is avoided, since the whole of the output from the combustor can be collected.

Instrument development

Under the heading, development of instruments, it is reported that the alkali meter has been in frequent and successful use in operation with the new pulverised fuel combustor (P.F. 5), and also in field trials. To aid the study of alkali release, high efficiency dust-collectors have been constructed ; these embody essentially a cyclone, in series with two electrostatic precipitators. Such apparatus will collect dust of all particle sizes ; and in particular any aerosols present in the gas stream are collected in the precipitators. A new design of recording dewpoint meter functioned satisfactory for a period of several weeks at Marchwood power station, and an improved model is under construction. Attention is now being focused on cleaning the sensing element, which is the only obstacle to making the instrument entirely automatic. There are obvious advantages in thus eliminating the human error in dewpoint determination ; further, the new apparatus enables continuous records of dewpoints to be obtained. It should thus prove possible to monitor accurately the effect of additives or other methods of corrosion control. An improved design of ring electrode and thermocouple in the B.C.U.R.A. dewpoint meter element has led to greater accuracy, and has facilitated the manufacture of these elements to meet the increased general demand.

Copies of the annual report (price 10s.) may be obtained from the Liaison and Publications Officer, B.C.U.R.A., Randalls Road, Leatherhead, Surrey.

American Equipment for Coal Sampling

By A. E. WILLIAMS, Ph.D., F.C.S.

ANALYTICAL chemistry has kept pace with the demands made upon it in ascertaining the composition and heating value of coal, but until recently methods of sampling often left much to be desired. As a result, the operators of steam-raising plant—in spite of the analyst's accuracy in reporting the results on a sample submitted for test—would frequently buy a coal vastly different than that intended. A concern using 1,000 tons of coal each week, for example, would lose a considerable sum of money each year if the fuel was bought on the basis of a 10 per cent. water content, as shown by sample-testing in the firm's own laboratory, when the bulk supplies as received contained up to 15 per cent. A similar discrepancy could easily arise with regard to calorific value of the fuel.

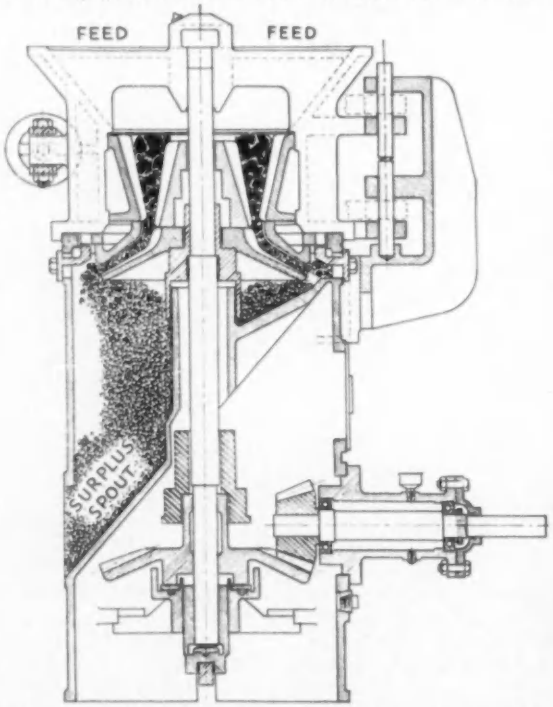
The conventional method of obtaining anything like an average sample from bulk solids is a time-consuming operation, and often occupies a period longer than that required for testing the sample ; eight hours is suggested as the minimum time if the sampler works hard and fast enough. The method consists broadly of crushing approximately 1,000 lb. of coal down to 1-in. pieces, on a hard, clean surface, and forming it into a coned pile, which is then turned over and over with a shovel to make a long, narrow pile. Alternate sections of the latter are then isolated, brought together and again coned, before crushing to ¼-in. pieces. This process of coning, crushing, and sectioning is repeated until ultimately a powder amounting to a few pounds in weight is obtained. The composition of this powder, if all the sampling operations have been carefully carried out, will bear some resemblance to the bulk material, but it is generally lower in moisture content, due to drying out while sampling. As the operation of sampling is just as important as the work to be done on the sample in the laboratory, the sampler is invariably regarded as a trusted servant of the company. It is questionable, however, whether the most devoted employee will not be tempted to discard rock and slate he finds in his sample, rather than go to the trouble of breaking this up ; it is much easier to break up coal than slate or rock. The temptation to reject hard pieces found in the sample is very great, and each rejection impairs the accuracy of sampling. It is evident, therefore, that if the work carried out by the sampler can be taken over by mechanical equipment—which is not liable to human failings—the sampler would be free for work elsewhere, while at the same time more accurate sampling would be ensured at a lower cost.

In the U.S.A., coal sampling is considered an integral part of any large coal consumer's activities, and this is emphasised by the fact that over 65 per cent. of large users sample all coal received to ensure that the material is purchased on a strict calorific value basis, and to avoid paying for deleterious material. The U.S. Government in their 1955 revision of Technical Paper 133, "Coal Sampling," refer to sampling as one of the most important features determining successful and satisfactory applications of the specification method of purchasing coal. Its purpose is in the first place to further means whereby the Government is assured of receiving the coal for which it has contracted ; secondly, to protect the interest of the Government by providing a means for determining liquidated damages if contractors fail to deliver coal of the quality guaranteed ; and finally, to provide the purchasing officer with an official basis for making his purchases on a sound, uniform technique. American experience shows that of the 65 per cent. of coal users who check their coal, some have found that they could use cheaper coal. Others have discovered that from accurate sampling, penalties can be exacted, and they receive them without contention from the contractor. Accurate samples of every rail-car or barge of coal, allow comparison of different coals, enabling the consumer to ascertain exactly how many heat units will be developed ; the user and contractor can then agree on the precise value of the fuel, and costs become proportionate to value received.

According to the U.S. Bureau of Mines, hand-sampling involves thirty-four different stages, and can take a day to complete ; on the other hand it requires a comparatively short time to pass the necessary amount of coal through a crusher-sampler. Under hand-sampling methods, excessive time taken in obtaining the sample permits moisture evaporation from the sample, and the final tests in the laboratory do not show the true amount of water in the bulk material ; so that a claim made on the laboratory test is underestimated. The unit for sampling which has been adopted in the U.S.A. is a crusher-sampler manufactured by the Sturtevant Mill Co., Boston, which is suitable for either coal or coke, as well as other minerals. It is capable of crushing 3-in. and smaller coal to sizes of 6-mesh and finer, with a large proportion to 20-mesh and finer, at the rate of one ton per hour. Coarse grinding capacities are larger. At the same time the unit automatically chooses a truly representative sample of the material fed to it, while eliminating thirty-two of the thirty-four steps required with hand-sampling.

The machine is driven by a motor rated at approximately 3-h.p., and the principle of operation may be seen from the accompanying sectional arrangement drawing. The horizontal or pinion shaft rotates at approximately 400 r.p.m. in a clockwise direction, when viewed from the end of the shaft. Looking down into the unit, the vertical shaft and crushing nuts rotate clockwise at 160 r.p.m. The coal is fed into the hopper, where it is gripped by the revolving coarse crushing nut and roughly crushed against the top of the liners. It is then passed by gravity to a revolving fine-toothed crushing disc and stationary liner, where the crushing operation is completed. Due to this gradual reduction process, and the rotating crushing action, the sample is thoroughly mixed and is ejected as a homogeneous, finely disinte-

grated and fully representative mixture of the fuel ; including, of course, the correct proportion of impurities. The fuel is then discharged at the periphery of the rotating disc, where, 5, 10 or 15 per cent. of the circumferential discharge is passed through an independent sample spout ; the balance being passed through a larger inclined surplus spout. By operating in this manner, the sample of coal is not taken directly after the rough crushing operation and then further reduced ; it is allowed



(Above). Diagrammatic arrangement of the Sturtevant coal crusher-sampler showing discharge from the surplus spout.

(Right). Coal being fed into a crusher-sampler unit, as supplied by the Sturtevant Mill Co., of Boston, U.S.A.

to remain until the material together with its impurities are finely disintegrated and thoroughly mixed.

By using different sizes of spout or chute for the passage of the sample, it is possible to obtain the 5, 10 or 15 per cent., according to the estimated amount of impurity that is expected in the material. Where the fuel is known to be high in impurity, a 5 per cent. chute would be used ; but for good quality material of low impurity content, the 10 or 15 per cent. chute would be employed. The sample chutes can be changed to facilitate the different qualities of fuels being sampled, and they can also be assembled at either side of the machine, to suit any specific location. The chute is adjustable by means of slotted holes and is normally raised upwards so as to just clear the lower nut in rotation. A handwheel adjustment is fitted on the lower part of the machine to give fine or coarse grinding as required ; clockwise movement of the wheel brings the grinding members together for fine crushing, while movement in the opposite direction will open the grinding members for coarser grinding. The handwheel is normally turned slowly while the machine is running, until the crushing nuts can be heard contacting the stationary grinding liners. When coal is fed to the machine, the grinding nuts centre themselves and operate without striking the liners. The cone and sideplates of the crusher unit are constructed to withstand long periods of heavy usage ; the experience of a New York concern which uses the crusher-sampler 16 hours each day, being that it is necessary to replace these elements every two to five years according to the hardness of the coal being handled.

A typical application of the crusher-sampler in American power stations is a group of three units installed at the Huntley station, New York. A sample is taken for testing as the coal is fed to the burners, while in addition, a composite weekly sample of the coal used is also tested. In this way the station staff maintain

a careful control and have statistics available to ensure that the cost of electricity, which can fluctuate in accordance with the calorific value of the fuel, is kept as stable as possible. One of the three crusher-samplers is in intermittent operation, processing 2,400-lb. of coal each week, while the other two process approximately 1,000-lb. of coal daily, ejecting a gross sample of 100-lb. These samples are sent to the Niagara Mohawk Power Corporation's Service Centre, in Buffalo, where the fuel is tested for volatility, grindability, fusion characteristics, etc. The resultant information is interpreted into kilowatt potential. At the power station, the coal is unloaded by a bucket-type unloader, it is then conveyed to the coal crushers and then sampled. It is next conveyed either to 25-cycle bunkers, or 60-cycle combination storage and bunker areas. For the 25-cycle plant, coal is gravity-fed from the bunkers via coal weighers, is then pulverised, and passed by compressed-air to the boiler burner equipment. In the 60-cycle plant, coal is delivered by conveyors to pockets over the coal crushers then to coal weighers, thence to pulverisers, and finally to the burner equipment at the boiler furnace.

New Swedish Plant for Power Generation and District-Heating

By J. GRINDROD, B.A.(Com.)

A NEW plant designed to generate electricity and in addition supply heat for a district heating system, is now under construction for Stockholm's Elektricitetsverk at Spånga, a new suburb of Stockholm, Sweden. Exhaust steam from three turbo-generators, having a total capacity of approximately 80-MW, and which are supplied with steam from three high-pressure boilers, each having an output of 286,650 lb./hr., will be conveyed to condensers, where the steam will serve as the heating medium for the circulating-water of the district heating system. Two 88,200 lb./hr. boilers at the present time being operated by Stockholms Elektricitetsverk in a large temporary central-heating plant, will also be installed on the new power plant site for use during periods when the turbines need not be in operation. These low-load boilers will also be frequently used during the summer months to satisfy the heat demand of the hot-water system. Finally, the boiler plant will include two electrically-heated steam boilers, each rated at approximately 15-MW, which will utilise surplus power from hydro-electric generating stations. The new installation has been designed for a maximum heat output of 594.2 to 694.4 million B.Th.U./hr.

Coal and oil fuel for the new station will be delivered by sea ; the coal being unloaded by a crane constructed by M.A.M., of Nurnberk, which company is also to be responsible for supplying an endless belt conveyor for transporting the coal from the harbour to the boiler bunkers. Oil will be stored in underground storage tanks.

The three high-pressure steam boilers will be supplied by AB Svenska Maskinverken, Södertälje, and are to be of the radiant-type with natural circulation and designed to operate at 1,192.8 lb./sq. in. and 968 deg. F. Arranged for either oil or coal firing, each boiler has been designed for a c.m.r. of 242,550 lb./hr. when fired with pulverised coal. The boiler maximum load of 286,650 lb./hr. can be attained with oil fuel or with pulverised coal and oil. The furnace walls are formed of closely-pitched, $1\frac{3}{4}$-in. dia. tubes suspended from the beam structure of the boiler by means of spring supports. Immediately above the tubes, there is a thin fireproof layer of reinforced tamping clay, outside which is fitted a sheet-iron sealing jacket, followed by layers of glass wool and finally a protecting cover of sheet-iron.

Flue gases from the furnace first pass through the superheater which is arranged in two separate sections with an intermediate steam cooler. Steam from the boiler dome is first passed through the low-temperature top section of the superheater, in the opposite direction to the flow of flue gases, then through the steam cooler and finally, in the same direction as the flue gas, through the high-temperature lower section. The superheater is of the horizontal self-draining type, built in the form of vertical screens suspended from the cooling tubes. The dimensions of the superheater and steam cooler are such that the steam temperature can be maintained at any desired value between 896 and 968 deg. F., from full load down to 198,450 lb./hr. This can be achieved equally as well with coal as with oil fuel. The steam cooler is of the injection type, manufactured in accordance with the Dolezal system, and the injection water will consist of condensate obtained by condensing saturated steam from the dome by means of the incoming feed-water. The pressure drop in that part of the superheater which is located between the dome and the point of injection, together with the pressure produced by the water column between the injection water condenser and the point of injection, will provide the motive power. Situated below the superheater, is an economiser supplied by E. Green & Son Ltd.

The flue gases having passed through the superheater sections then pass to the air preheater, which is of the Ljungstrom type. In order to prevent corrosion, should the temperature of the preheater sheet-iron panels fall below the dew point of the flue gases, steam batteries will be arranged to heat the incoming combustion air. Finally, the flue gases are carried via a dust separator and the i.d. fans to a single brick-built chimney arranged to serve all three boilers. As the Spånga station will be situated in a residential district, the dust separators are to be of a particularly high-efficiency, and if the essential requirements cannot be met, electrostatic precipitators or a combination of electrostatic precipitators and mechanical dust separators will be installed.

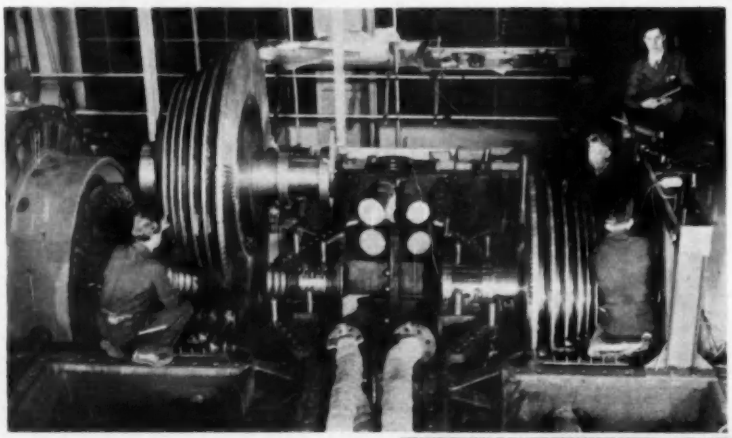
Each boiler will ultimately be served by two KSG impact coal pulverising mills, each of sufficient capacity for a steam production of 121,275 lb./hr. Initially, because of the unfavourable price of coal prevailing at the time of planning compared with that of oil, only one of the mills for each boiler was to have been installed.

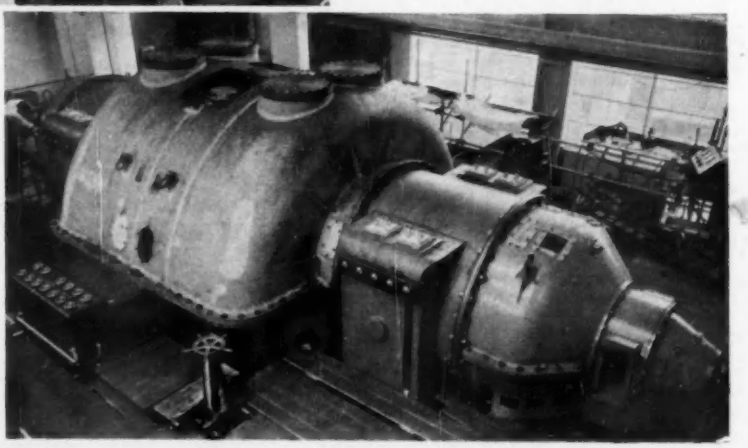
Three twin-rotor type turbines manufactured by Svenska Turbinfabriks AB Ljungström (STAL), of Finspong, are to be installed. Two of these units will be pure radial-flow turbines, equipped with hot-water condensers, intended for circulation water heating with exhaust steam from the turbines, while the third will be a combination radial-flow and axial-flow turbine.

From the high-pressure chamber of the No. 3 turbine, which is to be constructed in accordance with the radial-flow principle, the exhaust gases are carried either to a hot-water condenser, or via overflow valves to the low-pressure chamber developed in the form of two axial-flow turbines. The exhaust steam from the low-pressure chamber will be condensed in a cold-water condenser, the cooling medium being sea-water. The turbine can thus be operated either as a pure heat turbine, the exhaust steam being condensed in the hot-water condenser and utilised for heating purposes, or as a plain condensation turbine. In the former case, a small amount of

cooling steam has to be conducted through the low-pressure part of the turbine. Combined operation is also possible, the exhaust steam then being led simultaneously into both the condensers. In condensation service only, and with full steam inlet conditions, the aggregate develops approximately 32-MW, and in heating operation about 23-MW with a circulating-water temperature at the condenser outlet of approximately 212 deg. F. At lower circulating-water temperatures the turbine output will, of course, be greater.

In all the hot-water condensers the heating of the circulating water can reach a maximum of 248 deg. F. Each turbine yields slightly more than 19.84 million B.Th.U./hr. to its respective hot-water condenser at the maximum quantity of steam to the turbine of approximately 264,600 lb./hr. All the turbines are provided with non-regulated steam outlets at 8 and 3 atm. at the full steam supply. The outlet steam is essentially used for feedwater preheating, the 3 atm. steam in a pressure exhauster and the 8 atm. steam in a high-pressure pre-heater. In addition, No. 3 turbine is provided with an outlet for preheating the condensate from the cold water condenser.





(Left and below). Two views of the No. 3 turbine to be installed at the new Spånga power station, near Stockholm, Sweden. These show the turbine, which is of the combined radial-flow and axial-flow type, under construction for works testing by the manufacturers, Svenska Turbinfabriks AB Ljungstrom (STAL) of Finspong.

At the Spånga plant, the boilers and turbines will operate on the unit principle, forming three separate blocks, with shut-off lines between each block. From the high-pressure system steam can be transmitted via reducing and cooling devices to a low-pressure system for an operating pressure of about 25 above atmospheric pressure. This system can also be supplied from the low-load system and the electrically-heated boilers. The low-pressure steam is used for heating the circulating-water in special heat-exchangers, or reserve condensers, when the turbines are not in operation, or when the quantity of heat rendered in the turbine condensers is insufficient to cover the demand for heat of the distribution system. The low-pressure steam is also utilised for feedwater preheating, oil preheating, pressure sustenation in expansion vessels and other purposes.

Each boiler/turbine unit will be provided with a feedwater tank furnished with an exhauster, into which the condensate formed in the condensers is pumped, and where removal of aggressive gases takes place, as well as the preheating of the condensate by the steam from the 3 atm. turbine outlets. Feedwater at a temperature of approximately 221 deg. F. to 263 deg. F., depending on the turbine load, is pumped to the steam boilers via high-pressure pre-heaters, which raise the temperature of the feedwater to approximately 320 deg. F. at the full turbine load. Each boiler is provided with two electrically-operated feed pumps. The low-load and the electrically-heated boilers are fed by separate pumps.

Between the feedwater supply lines of the different boiler/turbine units there is a tie line that can be shut off, and by means of which a feedpump associated with one boiler may, if required, feed into the boiler of another unit. A combination of pumps also supplies water to the various feedwater tanks, regardless of whether the pressures in the tanks are the same or not. Dilution water is prepared by the evaporation of tapped steam or fresh steam from the low-pressure system, the feedwater to the evaporator being softened and partially freed from salts and gases.

The main elements of the circulating water system incorporated in the Spånga plant will be the turbine condensers, the reserve condensers, the hot-water accumulators, the expansion vessels and the circulating-water pumps. Both the reserve condensers will have a total capacity of 396.8 million B.Th.U./hr. By means of the hot-water accumulators, the turbine output may, to some extent, be disengaged from the prevailing demand for heat at any one time. In addition, a concentration for day-time consumption of the 24 hours heat demand is made possible whereby a considerable increase in the amount

of good counter-pressure is obtained. The three accumulators have a total volume of 234,639 cu. ft. Steam is utilised to maintain pressure in the expansion vessels.

The cooled return water from the various parts of the distribution system flows in a pipeline immediately outside the station wall, where the circulating-pumps of the return-line are connected. From these pumps, which increase the water pressure from about 3 to 6.5 atm. of overpressure, the water is carried to the turbine circuit pumps, by means of which the pressure drop in the hot-water condensers and hot-water accumulators, as well as the corresponding pipe system, is overcome. The water then passes, in series, through the different hot-water condensers and continues, via the main line pumps, into the distribution pipe-lines. By connecting the turbine condensers in series, they will operate at a higher average vacuum than if connected in parallel, enabling a greater exchange of energy and a higher maximum output to be obtained per unit of heat delivered to the circulating water.

Should the heat output of the turbine condensers exceed the demand for heat in the distribution system, the accumulators will be charged, part of the heated water being carried to the top of No. 1 accumulator and a corresponding quantity of cold water being let out at the bottom of No. 3 accumulator and from there led into the condensers. The accumulators will be drawn upon when the heat emitted in the condensers is insufficient for the needs of the distribution system, the water then flowing through the accumulators in the opposite direction. The quantities of water passing through the turbine condensers and hot-water accumulators will be regulated by a special governor actuating the speed of the turbine circuit pumps. This governor also determines whether charging or discharging is to take place. The maximum temperature in the accumulators will be approximately 248 deg. F.

In order to prevent the temperature of the water pumped into the distribution system becoming needlessly high, when, for example, the accumulators are being charged at higher temperatures than required by the system, a shunt-line from the pressure side of the return line pumps to the suction side of the supply line pumps enables cold return water to be mixed, when desired, with the warm water from the condensers. The extent of the return water mixture is controlled by a separate temperature regulator. If the accumulators are completely charged a so-called return cooler, utilising sea-water as a cooling medium, can be put in operation to assist in cooling the hot circulating-water in the turbine condensers. The return cooler will be designed for a capacity sufficient to eliminate the heat emitted by the turbine at full load. When necessary, the No. 1 turbine condenser can be connected to a sea-water pipe system and run in plain condenser operation. Since the No. 3 unit can also operate as a condensation machine the plant may be operated at full load, even though there is no prevalent heat demand.

All control equipment associated with the new plant will be concentrated in a separate control room, one section of which will be reserved for the electrical control equipment of the station.

RETIREMENT OF MR. L. F. JEFFREY

Mr. L. F. Jeffrey, B.Sc.(Eng.), M.Inst.C.E., M.I.Mech.E. M.I.E.E., who has just retired from the position of divisional controller, East Midlands Division, Central Electricity Generating Board, on the advice of his doctors, was educated at Whitgift School, Croydon, Battersea Technical College and London University. He received his practical training with James Keith & Blackman Co. Ltd., and during the 1914-18 war served in the Navy. After three years as assistant mechanical and electrical engineer at the Beckton works of the Gas Light & Coke Co., he became assistant constructional engineer with the Birmingham Corporation Electric Supply Department. In 1936 he joined the West Midlands Joint Electricity Authority as technical assistant and constructional engineer, becoming deputy chief engineer in 1938, chief engineer in 1942 and senior executive officer in 1948. On nationalisation of the electricity supply industry he was appointed chief generation engineer (construction), B.E.A. Midlands Division, and became divisional controller, East Mildands Division in 1951. At this time the policy of the Authority was to build a number of large generating stations operating at high steam pressures and temperatures, and situated on the banks of the River Trent, and near to the extensive East Midlands coalfield. It has been part of Mr. Jeffrey's responsibilities to supervise the design and construction of these new stations, which include Willington, Castle Donington, Drakelow, and Staythorpe, with High Marnham now under construction.

* * *

Kelvin & Hughes (Industrial) Ltd. states that its administrative offices are to be moved on August 11th, from 2, Caxton Street, Westminster, London, S.W.1, to their new building at Empire Way, Wembley, Middlesex. Tel.: Wembley 8888. Telegrams: Kelhue, Wembley.

* * *

We are informed that the head office of **Incorporated Plant Engineers,** at 12, The Parade, Solihull, Warwickshire, was closed on July 31st, and will re-open on the morning of August 6th, at 2, Grosvenor Gardens, London, S.W.1. Telephone: Sloane 0469. Telegrams: Planteng Sowest London. The secretary of the Institution is **Mr. R. F. Farmer.**

ASSOCIATION OF WATERWORKS OFFICERS

Wallace & Tiernan Ltd., Power Road, London, W.4, the well-known manufacturers of chlorination equipment for the elimination of slime and algae fouling in power plant, condensing plant, and other associated equipment, acted as hosts recently to sixty delegates from the South Eastern Area of the Association of Waterworks Officers. The visitors included Mr. D. W. Blackmore and Mr. B. T. Baldock, the latter being honorary general secretary of the association, Mr. R. A. F. Lees, chairman of the South Eastern Area Committee and Mr. W. G. Close, a past president of the Association. Wallace & Tiernan directors and officials received the guests, and an address of welcome was given by Mr. W. H. Wood, the chairman and managing director. Mr. Wood congratulated the delegates on belonging to a progressive Association, part of whose policy was to keep its members informed of all the latest developments relevant to their profession by the constant interchange of ideas. He pointed out that manufacturers, for their part, must be able to see a problem from the point of view of the man on the site. The delegates were then conducted on a tour of the works in order to see all the phases of the company's manufacturing activities, including the research and development laboratories. Among the fields of activity covered are dissolved oxygen recording, chlorine residual recording, dry chemical feeding, cathodic protection of steelwork, and chemical proportioning pumps. Equipment relating to these and other subjects was on display together with a collection of photographs and illustrative diagrams. Of particular interest to the visitors was a display of component parts, and the fact that upwards of fifty different materials had been employed in their manufacture. These included optical glass, monel, platinum, tungsten, gold, molybdenum, fibre glass, beryllium copper, silver, P.V.C. and many others.

* * *

W. C. Holmes & Co. Ltd., Huddersfield, have received an order from **Babcock & Wilcox Ltd.,** for two Holmes-Elex electrical precipitators to be installed for service with the two pulverised-fuel-fired re-heat unit boilers which will serve the 200-MW generating sets at the West Thurrock Power Station of the C.E.G.B. (Eastern Division).

RECENT *Equipment* AND *Accessories*

New method of scaffolding

In order to provide safe and complete access to the interior of the boilers at Marchwood power station during periods of inspection and overhaul, use is being made of specially designed scaffolding constructed from Self-Lock frames supplied and erected by the Mills Scaffold Co. Ltd. The frames, measuring 5-ft. by 2-ft. are passed one at a time into the boiler through a man-hole, and it is possible for thirteen men to erect or dismantle a complete scaffold in thirteen hours, as opposed to the three days normally required when using standard 2-in. dia. scaffold tube and fittings, the cost of the scaffold frames being absorbed by the saving achieved from the reduced shutdown period of one boiler. The boiler unit in which this equipment was first employed was a "Etaflow" two-drum boiler supplied by John Thompson Water Tube Boilers Ltd., with a m.c.r. of 550,000 lb./hr. at 925 lb./sq. in. and 915 deg. F. Designed originally for pulverised coal-firing, the boiler had been modified for oil firing, the modifications including the closure of the ashpit by fitting a false floor of fire bricks carried on a framework of tee-section girders. The scaffolding consisted of nine towers joined together with tie-bars, the centre tower being 70-ft. high, and carried directly on the false floor of the ashpit, the two banks of towers on either side being cantilevered off, and rising to a height of 56-ft. and 60-ft. respectively, the variation being due to the sloping roof of the boiler. Upon erection, the clearance of the inside face of the boiler and the scaffolding was found to be approximately 6-in. and to ensure complete stability of the structure, lengths of 2-in. dia. scaffolding tube (known as ledgers) were attached to the towers, the ends of the tubing butting up against the boiler walls. In this way, the scaffolding was stabilised on all four sides. Apart from boiler maintenance and inspection work, the Self-lock equipment is used throughout the power station for plant and building maintenance and repair work. (*Mills Scaffolding Co. Ltd., Trussley Works, Hammersmith Grove, London, W.8.*)

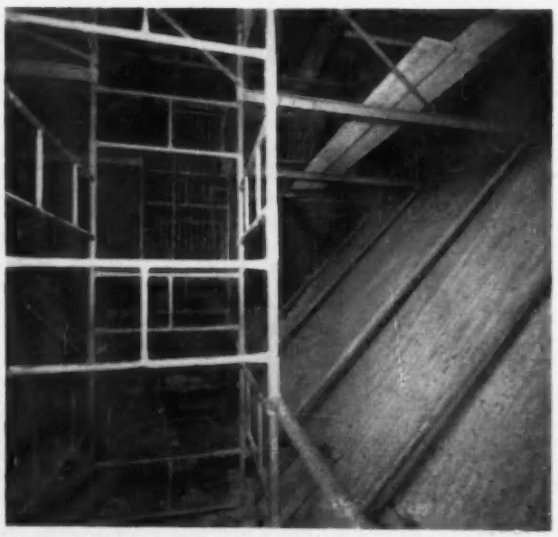


Fig. 1 (left). Interior of one of the boilers at Marchwood power station showing the Mills scaffolding cantilevered off from the central tower. (Mills Scaffolding Co. Ltd.)

A new indicating controller

Foxboro-Yoxall Ltd. announce the introduction of a new air-operated indicating controller, the M/41A. This new addition to their range of rectangular cased indicators, controllers and recorders provides "on/off" or proportional action for pressure, temperature, relative humidity or open-tank liquid-level applications. It is also made as a pneumatic receiver for 3-15 lb./sq. in. signals. For the new instrument standard Foxboro components are used, mounted in a dust and moisture proof cast aluminium case. A specially developed control unit provides "on/off" action to an eighth of 1 per cent. of the scale range. The pneumatic proportioning mechanism—fully-adjustable from a quarter of 1 per cent. to 25 per cent. of the scale—provides ample range for a wide variety of simple applications. The M/41A is easy to install and operate. Surface, flush, yoke or valve mountings are available and all operating adjustments are easily accessible. (*Foxboro-Yoxall Ltd., Redhill, Surrey.*)

Fig. 2 (right). The new Foxboro-Yoxall M/41A indicating controller (Foxboro-Yoxall, Ltd.)

Small induction motors

A new range of small induction motors from 1/40 h.p. to 1/10 h.p., and continuously rated to B.S. 170/1939 is announced by the General Electric Co. Ltd. Rolled steel shells with pressed-in wound stator cores form the motor bodies, with aluminium pressure-cast bearing brackets spigoted into each end. Sleeve bearings, diamond bored true with the bracket spigot, are fitted as standard and oil saturated felts provide efficient lubrication for prolonged running without re-oiling. The squirrel-cage rotors, cast in aluminium, are dynamically balanced and fitted with an accurately ground high-grade steel shaft. Connection leads are brought out external to the motor. All motors are electrically reversible and connection details are provided with each machine. An arrangement of thrust washers at the opposite driving end bearing permits the motors to be run in any position. The motors are available either as capacitor start and run or split phase. The capacitor start motors

develop moderate starting torque, have good overload capacity and are particularly suitable when starting conditions may be prolonged. These motors are provided with continuously rated impregnated paper capacitors in welded oval aluminium cans for separate mounting. The split phase motors, recommended where a higher starting torque is required and the load permits rapid acceleration to full speed, are supplied with separately mounted current-operated relays in moulded cases. The single-phase 50 c/s motors are available in standard voltage ranges : 200/220-V, 230/250-V and non-standard 100/110-V, and can be supplied for foot, resilient base, resilient cradle, or flange mounting. (*The General Electric Co. Ltd., Magnet House, Kingsway, W.C.2.*)

Electric-resistance rivet-heating machine

A feature of the new electric-resistance rivet - heating machine manufactured by Metropolitan-Vickers Electrical Co. Ltd. is that the heaters are ready for use instantly—the first rivet is ready within seconds of the machine being switched on. The saving in fuel costs and reduction in waiting time is appreciable, especially where the demand for heated rivets is somewhat irregular. Further advantages claimed for the equipment are simplicity of operation ; the heat is concentrated in the shank, the head of the rivet remaining comparatively cool ; rivets are visible while heating ; the machine requires practically no maintenance apart from electrode dressing ; and there are no fumes or ash. In the multi-head machines, separate transformers are used so that each may be set on a different tapping if more than one size of rivet is required simultaneously, and to prevent the loading of one head affecting the heating speeds on the others. This arrangement is also said to allow a damaged transformer to be removed for repair, and the other head(s) of the machine brought back into immediate production. The transformers are enclosed in sheet steel cases, on the fronts of which are mounted the electrode holders. The upper electrode of each pair is fixed in an easily pre-set position, according to the average length of rivet being used, while the lower one is spring-loaded enabling it to be drawn away by depression of a pedal for loading and unloading. In order that the machine may be used in semi-exposed positions, the standard range is of drip-proof construction, and lifting eyes are provided for convenience in moving them about the assembly shop. (*Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.*)

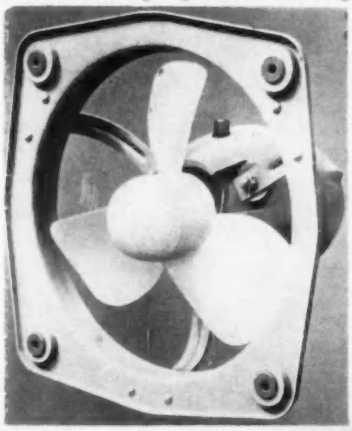


Fig. 4 (above). The Keith Blackman 6-in. diam., type APA, propeller fan. (Keith Blackman Ltd.)

Fig. 3 (left). The Metropolitan-Vickers three-head electric-resistance rivet heater, with pedal operation. (Metropolitan-Vickers Electrical Co. Ltd.)

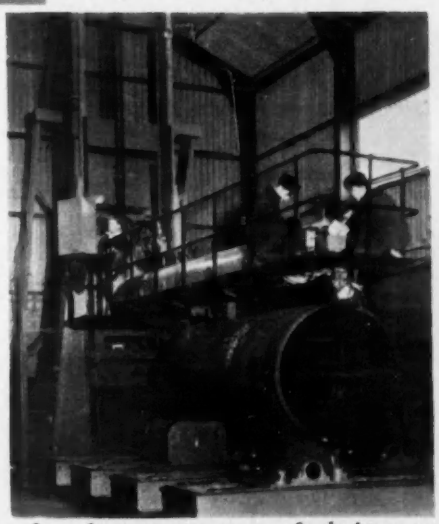


Fig. 5 (right). The Unionmelt installation for welding cylindrical pressure vessels at the Wolverhampton Works of John Thompson Ltd. (Quasi-Arc Ltd.)

6-in. dia. propeller fan

Among new products added to the Keith Blackman Ltd. "Tornado" range of fan engineering equipment, is the 6-in. dia. (type-APA) propeller fan which has been recently introduced to the well-established APA fan range, now available in sizes from 6-in. up to 48-in. The three-bladed anticlastic impeller of the 6-in. fan is manufactured throughout in high impact "Styrene" P.V.C. material. It is fitted with a domed nosed fairing which protects the end of the motor shaft. The larger fans in the range are fitted with sheet steel impellers. All fans in the range are driven by the company's totally-enclosed motors, constructed and tested in accordance with B.S.S. 170 : 1939 and B.S.S. 2613 : 1955. The 6-in. fan motor is wound for single-phase, 50 c/s, 200/250-V. (*Keith Blackman Ltd., Mill Mead Road, London, N.17.*)

Welding pressure vessels

At the Wolverhampton works of John Thompson Ltd., a Unionmelt installation supplied by Quasi-Arc Ltd. is now being used for the welding of cylindrical pressure vessels. The equipment comprises a Unionmelt U.E. welding head mounted on a high-lift boom which is 17-ft. 6-in. in length. A cat-walk with hand safety rails is incorporated to enable the operator to move freely between the welding station and a platform at the fixed end of the boom. This platform carries a hopper for welding powder, together with a powder recovery unit which returns unused powder to the hopper. The boom is raised and lowered by means of a substantial vertical lead screw driven by an electric motor. All main

electrical controls, including those for raising and lowering the boom, and traverse and rotation of the roller bed, are built into the bulkhead panel. They are situated conveniently near the operator who is carried by the machine in a suitably-designed lay trough. The raising and lowering of the boom permits external longitudinal and circumferential welding of vessels from 2-ft. 6-in. to 18-ft. dia. It also permits internal welding of vessels with diameters of 6-ft. 6-in. and upwards. The roller bed can support, traverse and rotate vessels of up to 18-ft. dia., 30-ft. in length and 48-tons in weight. (*Quasi-Arc Ltd., Bilston, Staffs.*)

New three-stage compressor

A new range of three-stage straight-line compressors (type TCB.3) introduced by Consolidated Pneumatic Tool Co. are designed for the continuous compression of air or other gases to pressures of up to 1,500 lb./sq. in., with a free air delivery of 242 cu. ft./min. at that pressure. For operating periods of not more than eight hours, the compressors may be run to give 238 cu. ft./min. at 2,000 lb./sq. in. In principle the new compressor is a further development of the company's class-T design, using a double acting low-pressure stage followed by a single-acting, opposed second and third high - pressure stage. The type-T frame, common to other units in this class, carries a Timken taper roller bearing supported shaft, two sets of bearings being used to equalise end thrust. A wedge adjusted connecting rod of forked end construction transmits the drive to a solid box-type cross-head, which overtravels its guides by half its length, the cross-head face being ground to fit the bore of the guide exactly and properly grooved for effective lubrication. A piston rod connects the cross-head and the piston, and a stuffing box with steel wipers located in the frame prevents oil from being carried out of the crank case on the piston rod. In the compression section, a double-acting first-stage piston interposed between second and third-stage pistons, acting in opposite directions, gives an almost equally divided load between forward and return strokes. Air is admitted at atmospheric pressure through Simplate valves to the two compression chambers formed on each side of the piston. Low-pressure air from the cylinder is then passed by further Simplate valves to multipass tubular intercoolers carried above the compressor. Water passes through the cooler in the opposite direction to the air flow, the coldest water thus being in contact with the coolest air as it leaves. From the intercooler, air passes to the second-stage, single-stage, single-acting cylinder, this cylinder being located at the crank end. From this cylinder it is further cooled in the second-stage multipass intercooler tubes before passing to the separator for removal of condensed moisture. The third-stage cylinder, of heat-treated forged steel at the outer end completes the compression cycle. A substantial provision for water jacketing is made to give the much lower operating temperatures than normally obtainable. Metallic packings are fitted where the piston rod passes through the 2nd stage cylinder head. (*Consolidated Pneumatic Tool Co. Ltd., 232, Dawes Road, S.W.6.*)

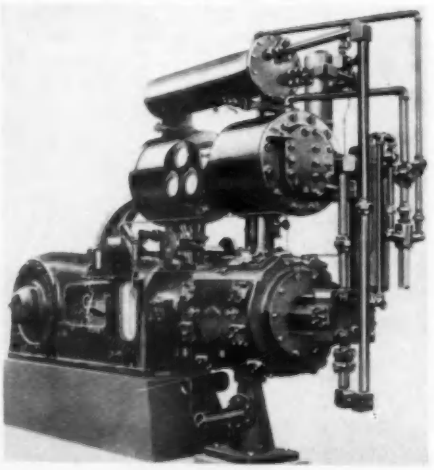


Fig. 6. A model from the range of type TCB.3, three-stage straight-line compressors. (Consolidated Pneumatic Tool Co. Ltd.)

Automatic feedwater treatment

The method of treating feedwater prior to it entering a boiler, by the addition of D.M. boiler solution, supplied by Houseman and Thompson Ltd., is well known, and it is therefore of interest to note that the company are shortly to make available a dosage pump, by means of which the amount of material injected can be accurately controlled. The pump, which is small, but of robust construction, can be installed in conjunction with reciprocating-type feed-pumps, and in operation ensures the minimum preselected amount of water-treatment, allowing for the specific requirements of the boiler installation. The unit is fully-automatic in operation, thus eliminating the need for the treatment solution to be injected manually. The quantity required can be set by infinite variation of the pump stroke, and can then be locked in that position. (*Houseman and Thompson, Ltd., D.M. House, Jesmond Road, Newcastle upon Tyne 2.*)

Solenoid-operated lever valve

A solenoid-operated lever valve recently introduced by Black Automatic Controls Ltd. has been primarily developed for application to industrial oil-burners using high-viscosity oils, but is also suitable for handling other fluids at high-pressures, as the valve is based on the use of a small electro-magnetic actuating force to open against a heavy load. The valve can be fitted as a normal "energised to open" pattern, in which case, when the solenoid is energised, the actuating lever pivoting on the fulcrum pin moves the valve spindle and cone out of the orifice against the incoming oil pressure, thus opening the valve. If the valve is required to have the reverse action, i.e. "energised to close," all that is necessary is to unscrew the nose cap, remove the valve cage, turn it round, and re-insert, screwing back on the nose cap to retain the cage in position. When fitted in this manner the inlet pressure keeps the valve open until such time as the solenoid is energised, and the actuating lever pivoting on the fulcrum pin moves the valve spindle and cone back into the orifice, thus closing the valve. Complete valve mechanism cages, having different sized orifices to suit any particular requirement, may be fitted. Spare nose caps and rear connectors tapped for different pipe threads are available to enable existing valves to be modified, thus simplifying stores procedure and stocking problems. (*Black Automatic Controls Ltd., Leafield, Corsham, Wiltshire.*)

Photoelectronic flame-failure control

A new flame-failure control equipment for oil burners, available from Photoelectronics (M.O.M.) Ltd., is housed in a pressed steel case, 6-in. by 4-in. by 2-in., and comprises a cadmium photoelectric cell (type MOM 90) relay with two sets of single-pole changeover contacts rated at 10-amps., 200-V, non-inductive and terminal connections. Red and amber indicating lights are also provided. The unit is mounted on the boiler front plate to view the main flame inside the furnace. As long as the photoelectric cell can "see" the flame, the relay will be held in,

and the amber light illuminated. Should the flame be extinguished for any reason the relay will drop out, the red light will be illuminated, the amber light extinguished and the supply to the solenoid valve will be cut, stopping the oil to the burner. All these operations are instantaneous. The photoelectric cell is protected from the heat by a suitable filter, and a further infra-red filter is provided to eliminate the effect of background radiations from the furnace brickwork. All components are capable of operating in ambient temperatures up to 167 deg. F., and the equipment is capable of working from 200/250-V a.c., single-phase, 50 c/s supply. Units are available for operation on d.c. supply, and fully-automatic programming units can also be supplied. [*Photoelectronics (M.O.M.) Ltd., Fotron Works, 63A, Kingston Road, London, S.W.19.*]

The boiler feed-pumps for the Hydro Electric Power Commission of Ontario's Lakeview Generating Station, Toronto, Canada (which when completed will be one of the largest thermal power stations on the American continent), have been ordered from the **Harland Engineering Co. Ltd.** Each of the six feed-pumps will be driven by a 5,000 h.p. motor through a Vulcan-Sinclair Size 22¼ Type D.S.T. fluid coupling supplied by **Fluidrive Engineering Co. Ltd.,** Isleworth, and will be serving the first of two 300-MW turbines in this important new power station. The Harland Engineering Co. Ltd. are amongst those firms who were visited by the Canadian Mission who toured this country last year. Harland boiler feed-pump sets are already operating in the Windsor power station of Ontario's Hydro-Electric Power Commission, and an order for their Richard L. Hearn power station is in hand. This latest order for Lakeview, received in the face of fierce international competition, will bring the value of Harland compensated boiler feed-pumps and motors sold to Canada to well over one million dollars.

* * *

A recent order received by **Metropolitan-Vickers Electrical Co. Ltd.** from the South of Scotland Electricity Board, and worth approximately £400,000, is for the 132-kV air-blast switchgear to control the output from the Hunterston Nuclear Power Station. The switching station is unusual in that practically the whole of the 132-kV equipment will be mounted indoors. The site is on the sea-coast in an area particularly prone to atmospheric salt deposit. The order covers the initial requirements of fifteen circuits, each equipped with a Metropolitan-Vickers 3,500-MVA Type GA6W4 air-blast circuit-breaker. Standard outdoor components will be used, but by special attention to the busbar and isolator layout, the station will occupy a rather smaller area than with the corresponding conventional layout. With the layout adopted a minimum of screening is required, giving a high degree of floor freedom. The circuit-breakers will be operated by compressed air and the isolators will be hand-operated. This, together with the introduction of ring-type current-transformers mounted in wall or isolator bushings, will obviate the use of any oil in the main building. This is the third order for a major switching station which Metropolitan-Vickers has received from the Board within the last two years, and in each case Type GA6W4 air-blast circuit-breakers have been selected. The previous orders were for fifteen for Kincardine and ten for Neilston, making a total of forty with the order for the Hunterston station.

We have received from **The Morgan Crucible Co. Ltd.,** Battersea Church Road, London, S.W.11, a new publication—"Crusilite Electric Furnace Element." "Crusilite" is a new non-metallic element, manufactured by the company, which, they say, makes electrical heating of furnaces both economic and convenient. The advantage of this form of heating—simplicity of furnace design, cleanliness and absence of flue gases—can, they claim, now be utilised in all temperature ranges up to 1,500 deg. C. The publication gives details of all the different applications and range of sizes available.

* * *

Mobil Oil Co. Ltd., and Socony Mobil Oil Co. Inc. of New York, have received an order for lubricating oils from the English Electric Co. in connection with their contract to supply turbines and alternators for the Priest Rapids Hydro Electric Project on the Columbia River, State of Washington, U.S.A. These turbines and alternators will be amongst the largest ever to be constructed. Mobil will supply 113,000 gal. of Mobil DTE heavy medium oil for the turbines and generators and approximately 145,000 gal. for the governor systems. The order also includes 65,000 gal. of transformer oil and 1,200 lb. of grease. It is estimated that this hydro-electric project will be completed in early 1960.

* * *

G. & J. Weir Ltd., Glasgow, have been notified that the first part of their large sea-water distilling plant in the Island of Aruba has commenced operation and is adding more than half a million gallons of fresh water daily to the island's supplies. The complete plant will be the largest in the world when it is in full operation, and the order was obtained by Weir's in keen competition with suppliers in a number of other countries. Four more of these plants are in course of completion, and will result in the Island of Aruba possessing a source of electric power and fresh water at the lowest economical cost to assist in developing the island's resources. Work is also proceeding on large installations to provide fresh water from the sea in the adjoining Island of Curacao, and in the British Colony of Nassau (Bahamas).

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Further appointments to the newly formed **Associated Electrical Industries Ltd.** Heavy Plant Division, managed by the British Thomson-Houston Co., are announced as follows: Mr. I. A. Ferguson, manager, large electrical machine sales; Mr. P. S. Clayton, manager, power rectifier sales; and Mr. J. B. Siddaway, manager, of the compressor sales department.

The Central Electricity Generating Board have appointed **Mr. W. T. Bamford,** B.Sc.(Eng.), A.M.Inst.C.E., A.M.I.Mech.E.; **Mr. J. Harvey,** A.M.I.Mech.E., M.Inst.F.; and **Mr. W. H. Foster,** A.M.I.E.E., M.Inst.F., to be chief generation engineers (operation) of the London, the South Eastern and Yorkshire Divisions respectively. Mr. Bamford joined the London Electric Supply Corporation in 1925 as a technical assistant at the Deptford East power station and from 1927 to 1928 was boiler house charge engineer at the Acton Lane power station. Subsequently, he successively held various positions at power stations in the London area including station superintendent at Fulham. He was appointed generation engineer (operation) in the London Division in 1950. Mr. Harvey, after holding various positions in the electricity supply industry became station superintendent at Woolwich and then transferred, in the same capacity, to Barking "A" and "B" power stations. In 1952 he was promoted to generation engineer (operation) with the London Division, Group IV. Mr. Foster joined the Yorkshire Electric Power Co. in 1943 as an assistant charge engineer at Ferrybridge power station. Three years later he went to Fulham as charge engineer, subsequently becoming assistant operating engineer. In 1949 he became assistant station superintendent at Brighton "A" power station, was appointed superintendent a year later, and then in 1952 took over the responsibilities of both Brighton "A" and "B" power stations. Mr. Foster was appointed generation engineer (operation) with the London Division in 1956.

* * *

The next standard course at the **Harwell Reactor School** on which places are available, starts on November 10th, 1958, and ends on March 6th, 1959. The fee for the course is £250 exclusive of accommodation. Applications will be considered from overseas as well as the United Kingdom, and this will be the seventeenth standard course at the school, where the 1,000 students who have attended to date include 231 from thirty-one other countries. Application forms and further details can be obtained from: The Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

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J. & J. Neil (Temple) Ltd., combustion engineers, Temple Park Iron Works, Glasgow, W.3, a company recently acquired by James Hodgkinson (Salford) Ltd., have been appointed sole representatives in Scotland for Bennis Combustion Ltd., Bennis Mechanizations Ltd., and Saxon Engineering Co. Ltd.; all members of the Hodgkinson Group of Companies.

OVERSEAS Steam Engineering Practice

Abridgments of recent articles in the colonial and foreign technical press, concerning design and progress in the technique of steam generation and power plant equipment

Turbo-alternator plant for New South Wales

Details are published in the current issue of *The Allen Engineering Review* of a new steam power station which was brought into operation during 1957 at Ulan in the central west of New South Wales. Local coal and water resources are used in the generation of electricity for the Ulan County Council distribution area in particular, and for the New South Wales grid. Power is generated at 11,000-volts for distribution to the Ulan Council's 33,000-volt system or to the N.S.W. Electricity Commission's 66,000-volt system. The station, which is 25 miles north of Mudgee, serves the Mudgee, Gulgong, Coolah and Coonabarabran districts. The main plant at Ulan comprises two 40,000 lb./hr. Babcock & Wilcox boilers and two Allen steam turbine-driven alternators, each designed for a power output of 3,125-kW, and operating with steam conditions of 400 lb./sq. in. and 750 deg. F. The condenser for each unit is designed for an exhaust vacuum of 28-in. of mercury at full load. The turbines are of the multi-stage, impulse-type with one Curtis and ten Rateau stages, and are fitted with conventional steam-chest incorporating an emergency and throttle valve, the latter valve being under the control of a centrifugal speed governor. The turbines run at a speed of 5,000 r.p.m., geared down to an alternator speed of 1,500 r.p.m., through a reduction gear of the double-helical, parallel-shaft type, forced-lubricated from the turbine oiling system. Each Allen basement-type condenser is mounted directly beneath the turbine exhaust branch, and works in conjunction with horizontal motor-driven condensate-extraction and circulating-water pumps and, a two-stage steam-jet ejector-type air-pump. Each turbine is provided with two bleed points, the first point providing steam for an evaporator and the second for feed-heating. Raw water is delivered to the single-stage coil-tube type evaporator via a raw-water heater and a float-operated level-control valve. The steam from the evaporator is led to the feed-heater where it mixes with the steam from the second bleed point, and the condensate from the heating steam is passed via a trap to the raw-water heater to give up heat to the raw water. The Mather & Platt alternators are of the duct-ventilated, rotating-field, salient-pole, single-pedestal-bearing type, each rated for a continuous maximum output of 3,125-kW at 0.8 p.f., 3,906.25-kVA, 3-phase, 50 c/s, 11,000-volts. Each machine is provided with a closed-air-circuit water-cooled air cooler, mounted in the foundation block. Automatic voltage regulators are provided to control the alternators running in parallel. The contract carried out by W. H. Allen Sons & Co. Ltd. also included the supply of the alternator control panels and certain feeder distribution switchgear.

High-pressure feedwater heaters

Among the features not previously incorporated in other supercritical-pressure power generating plants built in the United States, but included in the 250-MW unit at the present time being added to the Cleveland Electric Illuminating Co. plant at Avon, is the feedwater pumping arrangement, whereby feedwater will be raised to full boiler pressure before it enters the heaters. A cost study indicated that it would be an advantage to use two heaters in parallel for each of the high-pressure feedwater extraction stages. Four high-pressure heaters, built by Alco Products Inc., are of the U-bend type with integral desuper-heaters and drain-coolers. Each drain-cooler is designed for a 10 deg. F. approach to feedwater temperature entering the heater. The heater tubes are of $\frac{5}{8}$-in. o.d. monel metal. Expanded into carefully drilled and reamed holes, the tubes are welded to the forged-steel tube sheets. In preparation for welding, tubes and tube-sheet holes were cleaned by solvent and live steam. Minimum amounts of water soluble lubricant used during the rolling operation were completely removed prior to the highly sensitive welding operation which involved a two-pass technique with small-diameter monel type electrodes. Carefully controlled current and voltage conditions assured minimum dilution with the carbon-steel tube sheet. The longitudinal and girth seams of the shells and the nozzles were welded using qualified submerged-arc and manual metallic-arc procedures. To provide maximum accessibility to tube-side spaces for maintenance the water channel covers are sealed with breech-block type closures. The heater shell is welded to the distribution skirt, integral with the channel tube-sheet component, to eliminate a gasketed seal at this point. Flame cutting at a designated cutting line provides access to the shell space to permit removal of the shell. During such a cutting operation a flame deflector-plate protects the internal fittings. When operating at their design output the four high-pressure heaters will receive 1.72-million lb. of feedwater from the pumps at 4,730 lb./sq. in. and approximately 347 deg. F., and deliver it at 56° F. to the once-through boiler. (*Power*, Vol. 102, No. 6, p. 105.)

New electrode increases precipitator efficiency

Information relating to a new type of electrode for industrial gas and air cleaning equipment has been given by the Koppers Co. Inc., of America, following nearly a year of successful trial operation in steel works, power stations and cement works. It is known that collected material with this type of equipment tends to build-up on the collecting plates, and to a lesser degree on the energising wire electrodes, where its insulating effect tends to produce an unpredictable and uncontrolled pattern in the corona discharge which is the key factor in the precipitating action. The new electrode closely resembles ordinary barbed-wire as opposed to the conventional straight-wire energiser, and the company claim that demonstrations have proved that with the new electrode suspended vertically between the collector-plates, whatever build-up of material that may occur on the main wire, the barb points remain clean, with the result that the corona

discharge occurs constantly at these points. It is further stated that by the correct spacing of the barbs complete control of the corona discharge can be achieved throughout the entire precipitator. (*Power Engineering*. Vol. 62, No. 3, p. 76.)

Nuclear science and engineering

To forge a link between the universities and the Australian Atomic Energy Commission an Australian Institute of Nuclear Science and Engineering is to be established. It will help the universities to make use of the Commission's facilities for research, including the reactor at their Lucas Heights research establishment, near Sydney. The Commission and the ten Australian universities together will each contribute £A11,000 to the administrative cost of the Institute, and the Commission will also contribute £A50,000 towards the research fund besides providing a £A30,000 headquarters for the Institute next to the Lucas Heights station. Artificially produced radioactive isotopes flown from the United Kingdom are to be used in tests in a disused reservoir at Maitland, N.S.W., to determine the practicability of using artificial lakes as the source of condenser cooling water for a power station. Such a station may be erected by the N.S.W. Electricity Commission at either Ravensworth or Wallis Creek, in the Hunter Valley. The isotopes will be used as "tracers" to enable measurements to be made, at any level of the old reservoir, of the flow of warm water released from the power station at Maitland, and the time taken for it to mix with cool water. The announcement of the proposed experiments was made by Mr. H. G. Conde, the chairman of the Commission, who said that coal-burning stations will remain more economical in N.S.W. than nuclear power for at least ten years.

The fifth refresher course for works managers and works and plant engineers organised by the **National Industrial Fuel Efficiency Service** will be held at the Clarendon Laboratory, Oxford, from September 22nd to 26th, 1958. Included in the subjects to be covered will be "Coal—the future trend in production," "Oil—industrial applications," "Use of small coal in industry," "Industrial use of gas," "Electricity in industry," "Boiler efficiencies," "Steam utilisation," "Clean air—smoke alarm equipment," "Instrumentation," "Thermal insulation." Fees for resident members are £12 12s., and for non-resident members £7 7s. The complete programme and further details may be obtained from the secretary to the course, Mr. E. S. Watkin, N.I.F.E.S., Ailsa House, 181, King's Road, Reading, Berks.

* * *

A mobile exhibition featuring "NH" valves and other industrial valves and fittings manufactured by **Newman, Hender & Co. Ltd.,** recently left this country for a six months' tour through France, Italy, Switzerland and Western Germany. Various works will be visited to give interested personnel an opportunity of studying "NH" productions. Whilst in some areas the mobile showroom will be parked on a central site when visitors will be invited to inspect the exhibition. Forged-steel valves and fittings, Newman-Milliken lubricated parallel plug valves, Newman-McEvoy self-sealing conduit gate-valves and Vee-Reg regulating stop-valves are given special prominence. In addition, a small selection of general bronze and cast-iron valves and fittings are included, making up a display which will convey to visitors the very extensive range of manufactures available from the "NH" works.

* * *

The Standard & Pochin Bros Ltd., Evington Valley Road, Leicester, have issued a new publication (No. 177) which contains details of their range of P.R. "Uniform" pulley mounted centrifugal fans, which offer volumes and pressures beyond the scope of the company's P.R. "Variform" fans. The "Uniform" range are available in sizes from 6-in. to 72-in., and the publication includes performance tables for units from 7½-in. to 54-in. with outputs ranging from 200 to 20,000 cu.ft./min.

A new leaflet, "Stepping out with progress" has recently been published by **The Morgan Crucible Co. Ltd.,** Battersea Church Road, London, S.W.11. This describes the history and development of the company, and includes a complete list of products, and of subsidiary and associated companies, together with both line and half-tone illustrations.

* * *

A recent order placed with **Metropolitan-Vickers Electrical Co. Ltd.** is for a 225-MVA three-phase generator transformer for the Willington "B" power station of the Central Electricity Generating Board. The transformer will step-up the generator voltage from 16.5-kV to 295-kV at no-load for the super-grid. Although a number of super-grid transformers have been made for 100-MW generators, the new transformer will be one of the first to be made in this country for 200-MW generators. The transformer, which will be manufactured in the new transformer factory at Wythenshawe, will be oil-immersed, and will have forced oil circulation and oil-to-water heat-exchangers to provide the cooling. Fully assembled, the transformer will weigh 245 tons and will be 34-ft. long and 18-ft. wide, with a height of 25-ft. to the top of the bushings.

* * *

We have received from **General Refractories Ltd.,** Genefax House, Sheffield, 10, a new publication (No. 111 M.P. 3M. 5/58), dealing with their range of "Ferroclad" bricks. These are made in four grades from 100 per cent. chrome ore to 100 per cent. magnesia. These grades are chromite, chrome-magnesite, magnesite-chrome and magnesite. The brick filler and the steel casing are moulded together by hydraulic pressure. The company say that with metal-cased bricks it has been shown that in use in a furnace wall or roof structure the metal plates surrounding the brick become oxidised on the hot face and to a depth of 2 to 3-in., forming a continuous joint which prevents flaked portions of the brick falling into the furnace.

* * *

Crofts Engineers (Holdings) Ltd., Bradford, Yorkshire, announce the formation of a subsidiary company, Crofts U.S.A. Ltd. (with headquarters in Chicago), to deal with their various trading activities throughout America.

The Harland Engineering (Australia) Pty. Ltd., Melbourne, are to supply and erect the equipment to be installed in the Keepit power station and associated sub-station of the Electricity Commission of New South Wales. The plant comprises a 6,000-kW hydro-electric generating unit, valves, pumping equipment, crane, draught-tube gates, transformer, switchgear, control gear, remote supervisory equipment, batteries and cables. Power generated will be fed via a 66-kV transmission line into the Commission's interconnected network. The generating unit will be remotely-controlled from the Newcastle control centre, approximately 140 miles away, and will normally be run over the morning and evening peak periods, although there will be long periods when it will run continuously. The 8,500 b.h.p. vertical-shaft, Francis type water-turbine and the direct-coupled, 7,500-kVA water-cooled synchronous generator are to be manufactured by The Harland Engineering Co. Ltd., Alloa, Scotland, in their recently opened extension, specially built for the construction of large hydro-electric units.

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Mr. John Cruise has joined Geo. Salter & Co. Ltd., the well-known manufacturers of springs weighing equipment etc. of West Bromwich, as sales manager of the company's Salterpak division.

* * *

Crossley Brothers Ltd., Manchester, 11, are to install eight 500-kW diesel-engined automatic standby generator sets at the U.K.A.E.A.'s nuclear power station at Chapel Cross. These units are Crossley "HSN" six-cylinder, two-cycle scavenge pump diesel engines, with a bore of 10.5-in. and a 13.5-in. stroke, each direct-coupled to a Brush 240-V d.c. generator. They are fitted with electro-pneumatic starting gear, which automatically starts the engines on failure of the mains supply. The sets are of a large size for automatic starting, each being continuously rated at 800 b.h.p., at 600 r.p.m. All the engines are capable of running up to normal speed and taking the rated load within five seconds of failure of the mains supply. The compressed-air starting pressure is 250 lb./sq. in. A selector switch is provided to enable the engines to be run either singly or in pairs, according to any specific requirements.

Latest Power Plant Patents

These extracts from British Patent Specifications are reproduced by permission of The Controller of H.M. Stationery Office. (Complete British Specifications can be obtained from the Patent Office, 26, Southampton Buildings, London, W.C.2. Price 3s. 6d. each, both inland and abroad.)

Heat-exchanger

This invention relates in particular, but not exclusively, to boiler feedwater heat economisers. The sleeve length of Figs 1 and 2 comprises a central tubular portion (1) formed with two substantially co-planar diametrically-opposed longitudinal fins (2) and with a number of longitudinally-spaced, substantially triangular gills (3) tangential to, and positioned each side of the fins in order to present, in end view, substantially a square contour with the tube at the centre, and the fins extending diagonally, with those gills on one side of the fins being in register with respective gills on the other side. At one end the sleeve length is formed with a spigot portion (4) and at the other end with a complementary socket portion (5). A number of such sleeves, suitably of cast-iron, are "shrunk fitted" end-to-end on a tube (6), which may be of mild-steel, and an end sleeve having an extended spigot portion corresponding with a gland and packing in a casing member (10) is fitted. The tubes are mounted in parallel rows with fins (2) parallel, in order to provide substantially straight passageways for gas—one such passageway being indicated in dotted lines in Fig. 3. As will be seen from Fig. 3, the tubes in adjacent rows are relatively staggered and the gills of the tubes in one row protrude between those of the tubes of the adjacent row or rows without actually interleaving; this being in any case precluded by the gills being in alignment. This close packing of the gills is one of the advantages afforded by this invention. As shown in Fig. 4, the ends of the tubes are connected with the usual bends (11) and headers (12). Instead of forming the fins and gills of cast-iron, they may be of light alloy, such as an aluminium-base alloy, shrink-fitted or cast on to steel tubing. *British Patent No. 795,326 issued to Senior Economisers Ltd. Complete specification published May 21st, 1958.*

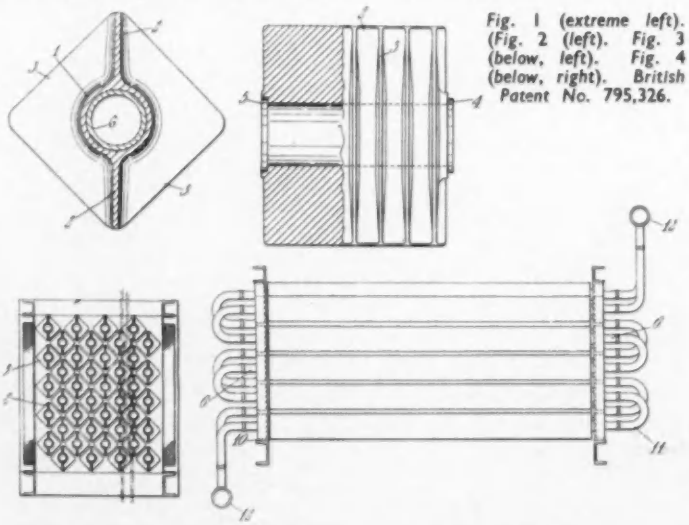
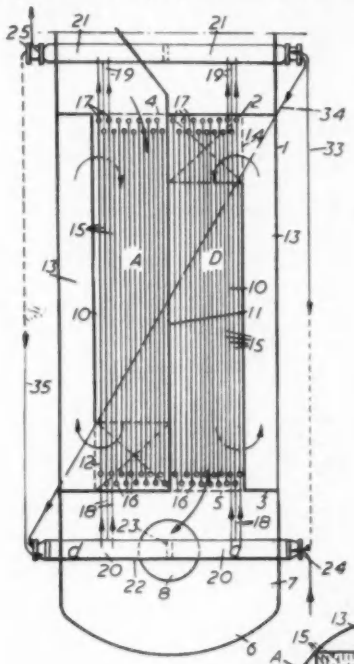


Fig. 1 (extreme left). (Fig. 2 (left). Fig. 3 (below, left). Fig. 4 (below, right). British Patent No. 795,326.

Heat-exchanger and heat-exchanger tubes

This invention relates to tubular type heat-exchangers and heat-exchanger tubes. It is particularly concerned with a form of heat-exchanger suitable for heating a fluid by means of the sensible heat contained in hot gases of relatively low temperature, but supplied in large quantities under high-pressure. The invention may be applied especially to the economisers and generating sections of a steam generating plant in which a number of units are arranged in series in a gas-path with each unit producing steam at a pressure corresponding to the gas temperature at the outlet of the unit so that a supply of steam at different pressures is obtained. In tubular heat-exchangers the flow of the heating gases is usually effected in a direction transverse to a bank of tubes through which the fluid to be heated flows, and which tubes may be of the gilled type. Nevertheless, certain heat-exchangers employ longitudinal flow of the heating gases along the tubes, which are not gilled but are spaced very close together. These arrangements could not be applied to the case under consideration, by reason either of too high a value of pressure drop, or of insufficiently low exchange coefficients, which would involve excessive dimensions and weight. The invention provides a solution to this problem. The heat-exchanger shown in outline in Figs. 5 and 6 is an economiser at the inlet of the first of a series of steam-generating units of the type referred to above. This economiser occupies a lower part of a vertical cylindrical casing (1) which is traversed by the hot gases from top to bottom. Inside the casing (1), two transverse partitions (2 and 3) with an inlet (4) and an outlet (5) for the gases, define the height of the heat-exchange zone of the economiser. At the base of the casing, an end (6) co-operates with the partition (3) in delimiting an outlet chamber (7) provided with a nozzle (8) for the exit of gases cooled in the heat-exchanger. The heat-exchange zone of the economiser is a central space of square cross-section bounded by a prismatic partitioning (9) extending between the partitions (2 and 3) and contained in the casing (1). The zone is divided into four equal ducts of square cross-section (10) by longitudinal partitions (11). Each of the ducts has a gas inlet at its upper end, and a gas outlet at its lower end. Thus, at the top of one of the ducts is the gas inlet (4) and all the other ducts have gas inlets (14) formed in the partitioning (9) and leading from respective peripheral segmental passages (13), whilst at the bottom of another of the ducts is the gas outlet (5), and all the other ducts have gas outlets (12) also formed in the

partitioning (9) and leading to respective passages (13). The gases flow downwardly in the four ducts (10) in the sequence A, B, C and D, and



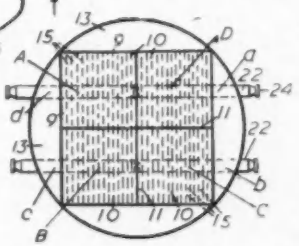
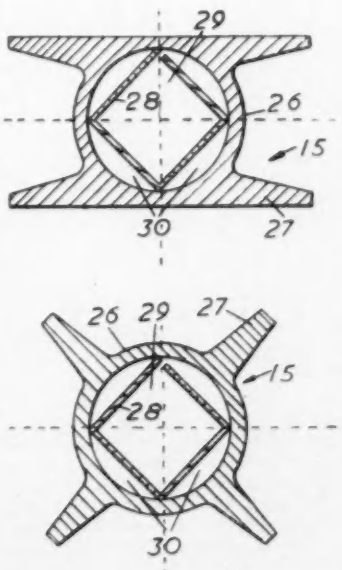


Fig. 5 (above).
Fig. 6 (right). British Patent No. 796,004.

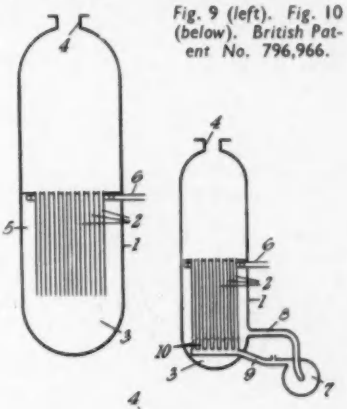
upwardly in three of the passages (13) in sequence. Each duct (10) is occupied by a longitudinal tube nest (15) formed of rows of tubes, the lower ends of which are welded to inlet cross-headers (16), the upper ends being welded to outlet cross headers (17). The headers (16) of the four tube-nests are connected by tubes (18) to respective distributors (20). The distributors (20) are formed by two large cross-tubes (22) each divided in the middle by a partition (23). The collectors (21) are of similar construction. The tube nests are composed of similar tubes, each formed with four external, integral, longitudinal ribs forming gills (27) projecting from the tube wall (26). The gills (27) are symmetrical with respect to two transverse axes at right-angles to one another, and drawn with respect to the tube cross-section and comprise pairs of gills which project in opposite directions. In Figs. 7 and 8 such transverse axes are indicated by dotted lines and it will be seen that a pair of gills on one side of each axis is symmetrical with respect to the pair of gills on the opposite side of the axis. The height of the gills is approximately equal to the external radius of the tube, and their thickness is approximately equal to that of the tube wall, but the gills thicken towards their roots. *British Patent No. 796,004 issued to Babcock & Wilcox Ltd. Complete specification published June 4, 1958.*



Figs. 7 and 8 (below). British Patent No. 796,004.

Nuclear reactor

This invention relates to nuclear reactors in which liquid circulates, particularly boiling water reactors. In a boiling water reactor nuclear fuel is housed in a series of ducts formed within a reactor vessel. The fuel ducts are surrounded by water which is caused to circulate through the ducts for the purpose of cooling the nuclear fuel. In removing heat generated by the nuclear fuel, the water circulating through the fuel ducts is raised to boiling point, and a mixture of water and saturated steam emerges from each fuel duct. The steam passes from the reactor vessel and can be used as the working medium in a conventional or other power plant. The water emerging from the ducts with the steam is conducted through a space between the fuel ducts and the walls of the reactor vessel, and eventually recirculated through the fuel ducts by means of circulating pumps. In practice, the volume of water which needs recirculation is large and difficult to handle, especially in view



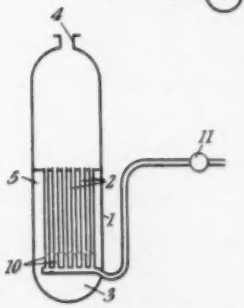


Fig. 9 (left). Fig. 10 (below). British Patent No. 796,966.

of the rate at which circulation is effected. This entails the use of large pumps located outside the reactor vessel, and large ducts passing through the walls of the vessel. To avoid the necessity of using large pumps, and the difficulties associated with the passage of large ducts through the walls of the vessel, use can be made of natural circulation. In this method, circulation is induced by the difference in density between the water in the space between the fuel duct and the vessel walls and the water-steam mixture in the fuel ducts. Unfortunately, the available head in such a method is relatively small, and this limits the rate at which the water can be circulated. The object of the present invention is to provide means for increasing the available circulating head. Means are therefore provided for assisting circulation of the liquid through the ducts over the fuel. These means comprise nozzles arranged at the inlets of one or more fuel ducts, through which nozzles, a

proportion of the liquid is injected into the ducts ; a space for the flow of liquid being formed between each nozzle outlet and the wall of the duct associated with the nozzle. A conventional arrangement for natural circulation is shown diagrammatically in Fig. 9. Here, a reactor vessel (1) comprises a number of ducts (2) immersed in water (3). In each duct (2) is housed nuclear fuel, and water flowing over the surfaces thereof in the ducts (2) is raised to boiling point. A mixture of water and steam issues from the top of the ducts (2). The saturated steam from the mixture passes from the top of the reactor vessel (1) through duct (4) and can be used as working medium in a power-generating plant. The water from the mixture issuing from the top ducts (2) recirculates downwards through an annular space (5) between the reactor vessel (1) and the fuel ducts (2). A typical power plant using the steam produced in the reactor may comprise means for superheating the steam, a turbine for expanding it, and a condenser for condensing the steam leaving the turbines. In such plants the condensate can be used for cooling the water in the space (5) in the reactor by introducing the condensate through a pipe (6) adjacent the tops of the fuel ducts (2). In carrying the invention into practical application in the form shown in outline in Fig. 10, for increasing the rate of circulation of water, a circulating-pump (7) withdraws water from the reactor vessel (1) through pipe (8) and returns it to the vessel through pipe (9) to nozzles (10) located at the inlet ends of one or more fuel ducts. The water pumped through nozzle (10) at high velocity produces an injector effect and assists the natural circulation of water. Instead of withdrawing water from the reactor by means of a pump and then supplying it to the nozzles as shown in Fig. 10, the condensate from the turbines can be used for supplying nozzles (10) through pump (11) as shown in Fig. 11. *British Patent No. 796,966 issued to C. A. Parsons & Co. Ltd. Complete specification published June 25th, 1958.*

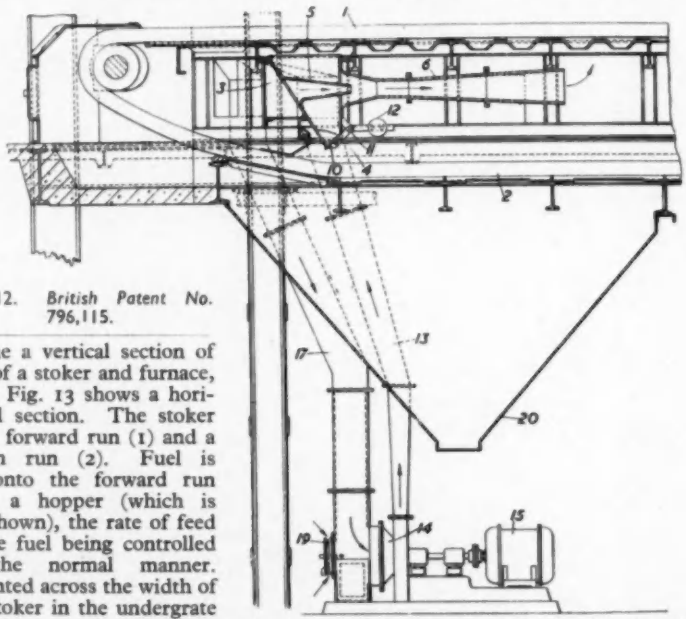


Fig. 12. British Patent No. 796,115.

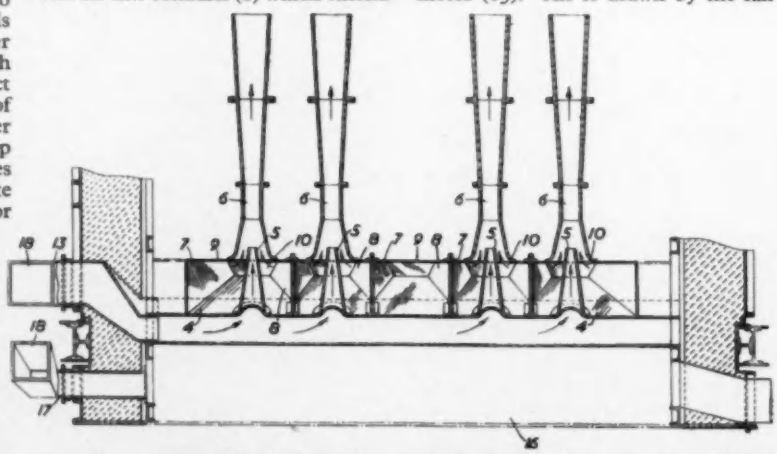


Fig. 13. (right). British Patent No. 796,155.

Moving-grate stokers

This patent relates to moving grate stokers such as those of the chain-grate and travelling grate types. According to the invention the ignition of low volatile fuels is improved by mounting between the forward and return runs of the grate a nozzle for directing a stream of gas into a conduit in order to create an entrainment zone within the vicinity of the conduit. This entrainment zone is so arranged that combustion products are drawn over fuel on the grate prior to the entry of that fuel into a combustion zone. Fig. 12 shows in outline a vertical section of part of a stoker and furnace, while Fig. 13 shows a horizontal section. The stoker has a forward run (1) and a return run (2). Fuel is fed onto the forward run from a hopper (which is not shown), the rate of feed of the fuel being controlled in the normal manner. Mounted across the width of the stoker in the undergrate space between the runs of the stoker is a duct (3), one wall (4) of which is inclined and has a series of nozzles (5) secured to it. These nozzles are directed towards, and co-operate with, venturi-like conduits (6) which extend away from the nozzle in the undergrate space. Surrounding each nozzle is a zone bounded by part of the inclined wall (4), side walls (7 and 8) and a part of a vertical wall (9) in which is formed the entrance to the associated conduit (6). As can be seen from Fig. 13 the side walls (7 and 8) are inclined to the vertical, so that with the part of the wall (4) and the wall (9) they form a hopper, the lower end of which as indicated in Fig. 12 has an outlet gate (10) pivotally mounted at (11) and having a counterbalancing weight (12) which normally retains the grate (10) in the closed position shown. Air under pressure is supplied to the nozzles (5) via the duct (3) from a duct (13) connected to the outlet of a fan (14) driven by a motor (15). Air is drawn by the fan from a forward air compartment (16) in the undergrate space of the stoker, via a duct (17). Dampers (18) are mounted on the ducts (13 and 17) and a control damper (19) for atmospheric air may be provided as shown in Fig. 5. In operation, air under pressure passing from the

nozzles (5) entering the conduits (6) creates entrainment zones in the hoppers and gases are drawn in through the upper open side of each hopper. The disposition of the entrainment zone is such that with the furnace in operation, combustion gases are drawn back from the combustion zone in the furnace, over fuel on the stoker immediately above the entrainment zones, and are then drawn along the conduits (6) and discharged into the main supply of forced-draught air for the stoker, fed to the latter slightly in advance of the ends of the conduits (6). The hot combustion gases pass through fuel just fed on to the stoker. This so-called "green fuel" is thus dried, so promoting the primary combustion of the green fuel and preparing it for combustion in the combustion zone proper of the furnace. *British Patent No. 796,155 issued to J. W. Wray.*

Mr. W. J. Carfrae, B.Sc.(Eng.), M.I.E.E., has been appointed assistant chief electrical engineer of the British Thomson-Houston Co. Ltd. Since 1927 Mr. Carfrae has been associated with the design and development of turbo-driven alternators. In January 1948 he was appointed manager of the company's turbo-generator engineering department and in May, 1957, manager of the turbine-group engineering department with responsibility for the design engineering staffs engaged on steam turbines, turbo-generators, gas turbines, gears, and compressors. He has been concerned with many important developments affecting electrical design and performance, including the first BTH hydrogen-cooled alternators, and hydrogen-coolers, developed to meet the required conditions. He introduced the directly-coupled double-bearing exciter with various forms of flexible drive which has successfully eliminated much "tuning-up" during commissioning. He was instrumental in the introduction of the use of the "d.c. current transformer" for measurement of alternator field current, and has also investigated conditions of exciter and slipring brushgear and instituted modified designs resulting in improved performance. In 1946 and 1957 Mr. Carfrae visited the U.S.A. to study hydrogen cooling practice on alternators and current steam turbine practice. In 1956 he was assigned to special duties in connection with turbine manufacture.

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Mr. Leslie L. Hughes, A.M.I.E.E., has been appointed to the technical staff of the Electrical Development Association as assistant to Mr. Phillip Honey, A.M.I.E.E.

* * *

Dr. W. F. Coxon, M.Sc., F.R.I.C., F.I.M., M.Inst.F., is now practising under the name of Co-ordinated Industrial Publicity at 152, Fleet Street, London, E.C.4 (tel. : Fleet Street 3521), specialising in all aspects of technical publicity.

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Mr. P. H. N. Ulander, M.I.Mech.E., F.Inst.F., has resigned his position as executive technical director of James Howden & Co. Ltd., but remains a director of the company.

* * *

Dr. Peter Roderick has been appointed assistant chief metallurgist in the steel division of The Steel Co. of Wales Ltd.

* * *

Electroflo Meters Co. Ltd. announce that **Mr. N. Maggs** has joined their systems engineering division as contracts engineer, and **Mr. F. Cheventre** as outside representative in the London and southern England areas.

F. W. Brackett & Co. Ltd., Colchester, have recently received several orders for their automatic travelling-band screens, for screening condenser cooling-water in nuclear power stations now in course of construction. These include six screens, 5-ft. wide, for Berkeley nuclear power station, each to pass 3,500,000 gal./hr. of water ; eight screens, 5-ft. wide, for Hinkley Point, each to pass 4,305,000 gal./hr. ; and eight screens, 5-ft. wide, for Hunterston, each to pass 3,240,000 gal./hr. In addition to automatic band screens, two nuclear power stations will be equipped with a considerable number of Brackett self-contained twin-strainers, in sizes up to 18-in. bore.

* * *

A new 50-page loose-leaf catalogue which contains information relating to the company's products and services has been produced by the **Magnetic Valve Co. Ltd.** Full details of their standard-type magnetic valves are given, together with information on valves available for special applications. Other sections deal with ancillary equipment, including rectifier sets, thermostats, electro-thermal links, pipe strainers, magnetic control switches and engine emergency cut-out switches. Three pages are devoted to general data on magnet valve installation and service. Useful charts and conversion tables are also included. Copies of MVC publications are available on application to the company at 28, St. James's Place, London, S.W.1.

* * *

A contract for thermal insulation work in connection with the nuclear power station now being constructed by the A.E.I.-John Thompson Nuclear Energy Co. at Berkeley in Gloucestershire, has been awarded to **The Cape Asbestos Co. Ltd.** The plant involved includes the two 80-ft. high reactor vessels, sixteen heat-exchangers, CO_2 ducting and main steam pipes. The materials used will be the company's "Caposite" moulded amosite asbestos insulation and "Rocksil" rock wool insulation.

* * *

A new leaflet available from **Danks of Netherton Ltd.,** Netherton, Dudley, deals with the company's oil or gas-fired "Supapak" packaged boiler. These are manufactured in a range of capacities from 1,500 to 17,500 lb./hr., from and at 212 deg. F.

* * *

The Goodyear Tyre & Rubber Co. (Great Britain) Ltd. announce the appointment of **Mr. W. J. Gaffney** as chief engineer for all their production plants in Great Britain. He was formerly manager of engineering and maintenance at the Wolverhampton plant, a position which has been recently taken over by **Mr. R. E. Ward** from Akron, Ohio.

The board of directors of the National Industrial Fuel Efficiency Service announce that the British Productivity Council have appointed **Dr. W. Angus Macfarlane** as a director of N.I.F.E.S. At the directors' 50th meeting on July 17th, Dr. Macfarlane was unanimously appointed as managing director of N.I.F.E.S. It will be recalled that N.I.F.E.S. became operational in May, 1954, as a non-profit making organisation, and the appointment now of Dr. Macfarlane as managing director coincides with the 2,000th detailed Heat and Power Survey being carried out by N.I.F.E.S. engineers. In all, nearly 50,000 visits to plants have been made by N.I.F.E.S. engineers to advise on the efficient use of fuel.

* * *

In a publication entitled "Electroflo Service," **Electroflo Meters Co. Ltd.** a member of the Elliott-Automation Group, outline the extent of their activities in the research, application engineering, installation-commissioning and maintenance fields for their complete range of instrumentation and automatic control equipment. Of particular importance is their fluid dynamics laboratory which is used regularly by major plant manufacturers to investigate fluid flow problems and also in the design of ducting, flow piping layouts, valves, etc. The publication shows how the application engineering divisions are specialists in the requirements of different industries such as steel, gas, electricity, water, etc., whilst the installation department co-ordinates a comprehensive service including design, manufacture, application studies, layouts, commissioning and maintenance under one single responsible department. Reference is also made to the free initial service and the extensive maintenance service based in major towns in the United Kingdom. The publication explains the service and technical resources used in the manufacture of Electroflo instruments and control systems.

* * *

The use of transistors in a capacitance-operated level control is the subject of a special feature in the current issue of "Electricity in Industry," the technical review published by the **Lancashire Dynamo Group.** This issue also contains a description of a monitored earth safety unit, providing a safe method of using mains supply to operate portable electrical equipment.

* * *

The Incandescent Heat Co. Ltd., Cornwall Road, Smethwick, Birmingham, have issued a new leaflet (No. V26a) which replaces a previous publication (No. V26), and deals with the company's standard gas-fired furnace for general purpose heat-treatment.

Notes Personal and Industrial

Mr. F. Foster, M.Sc., A.M.I.E.E., has been appointed managing director of Crompton Parkinson (Stud Welding) Ltd., a recently-formed subsidiary company of Crompton Parkinson Ltd. Mr. Foster joined the general sales department of Crompton Parkinson Ltd. in 1937, became sales manager of the plant section of the Overseas Division in 1948 and served in that capacity until 1953, when he was appointed general manager of the Cyc-Arc Stud Welding Division. When the new subsidiary company was formed in December, 1957, Mr. Foster was appointed a director and retained his responsibility as general manager.

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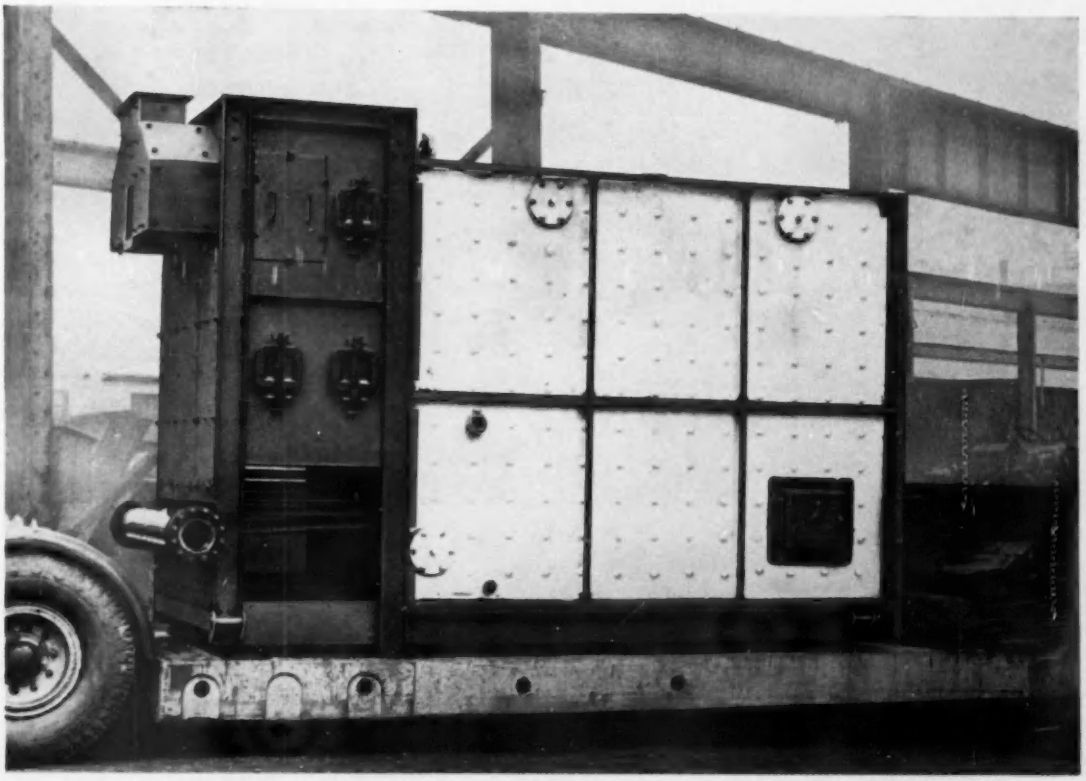

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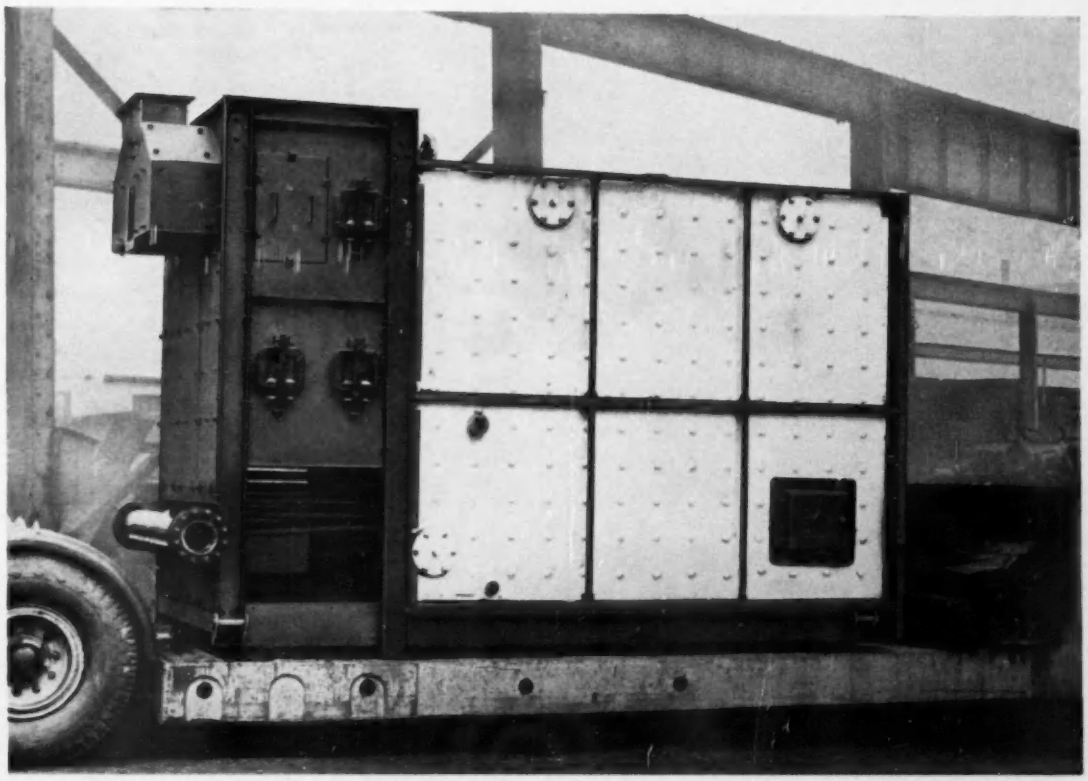

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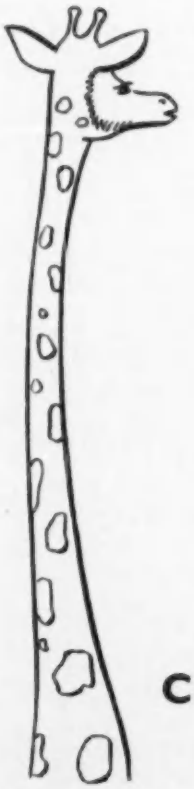

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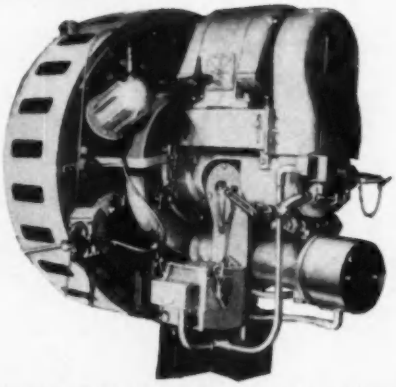

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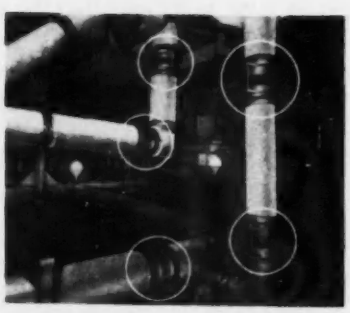

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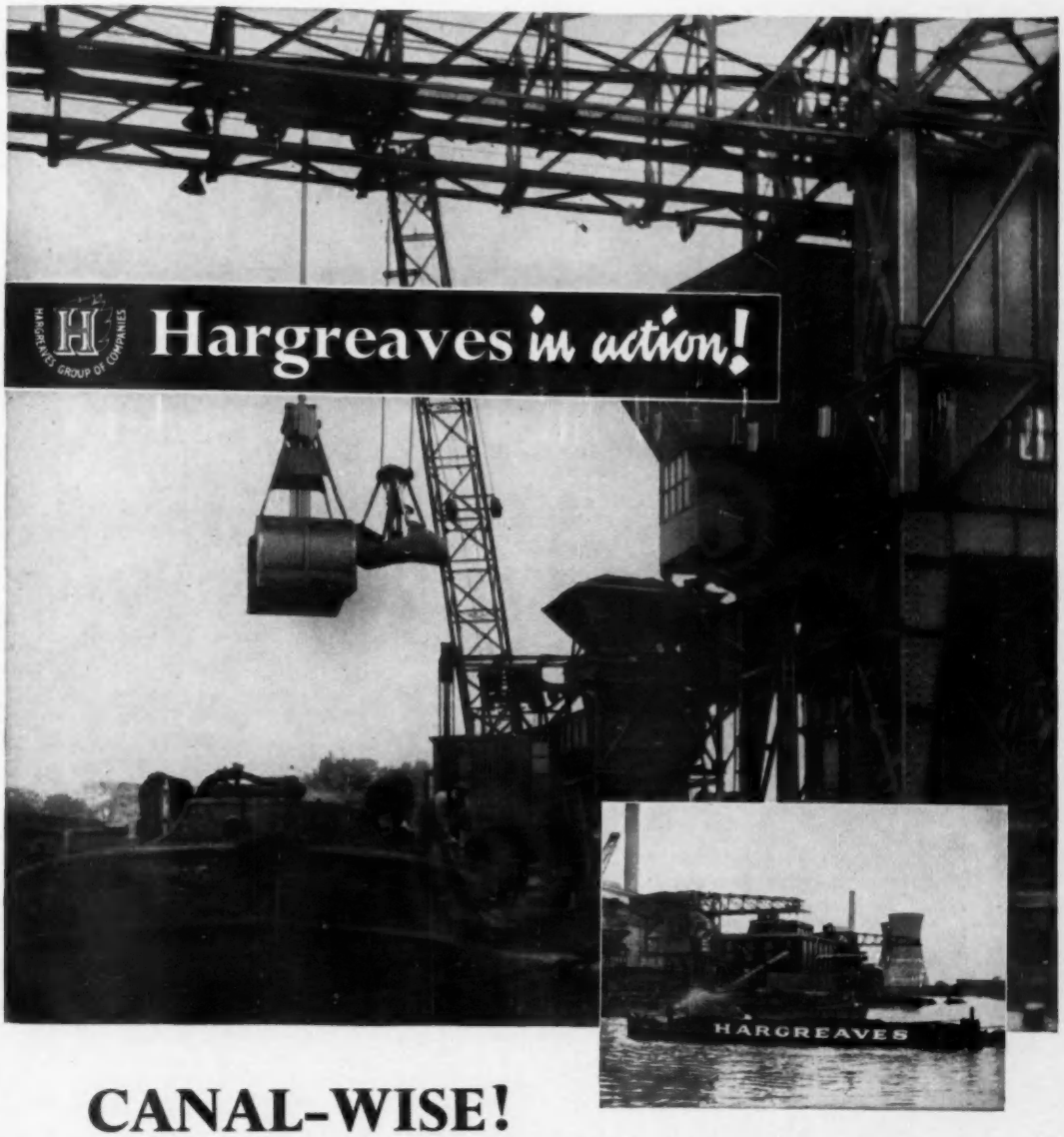

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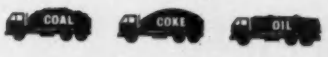

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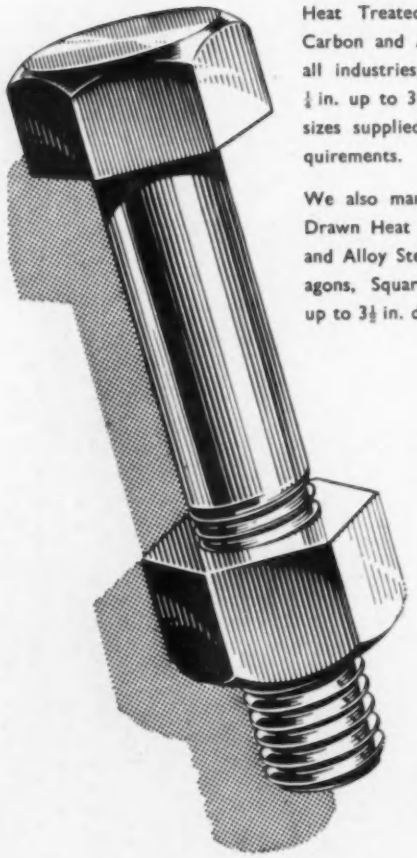

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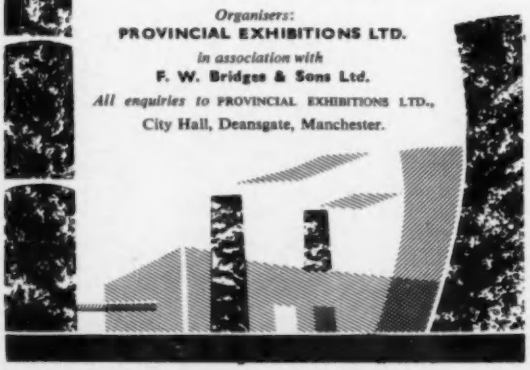

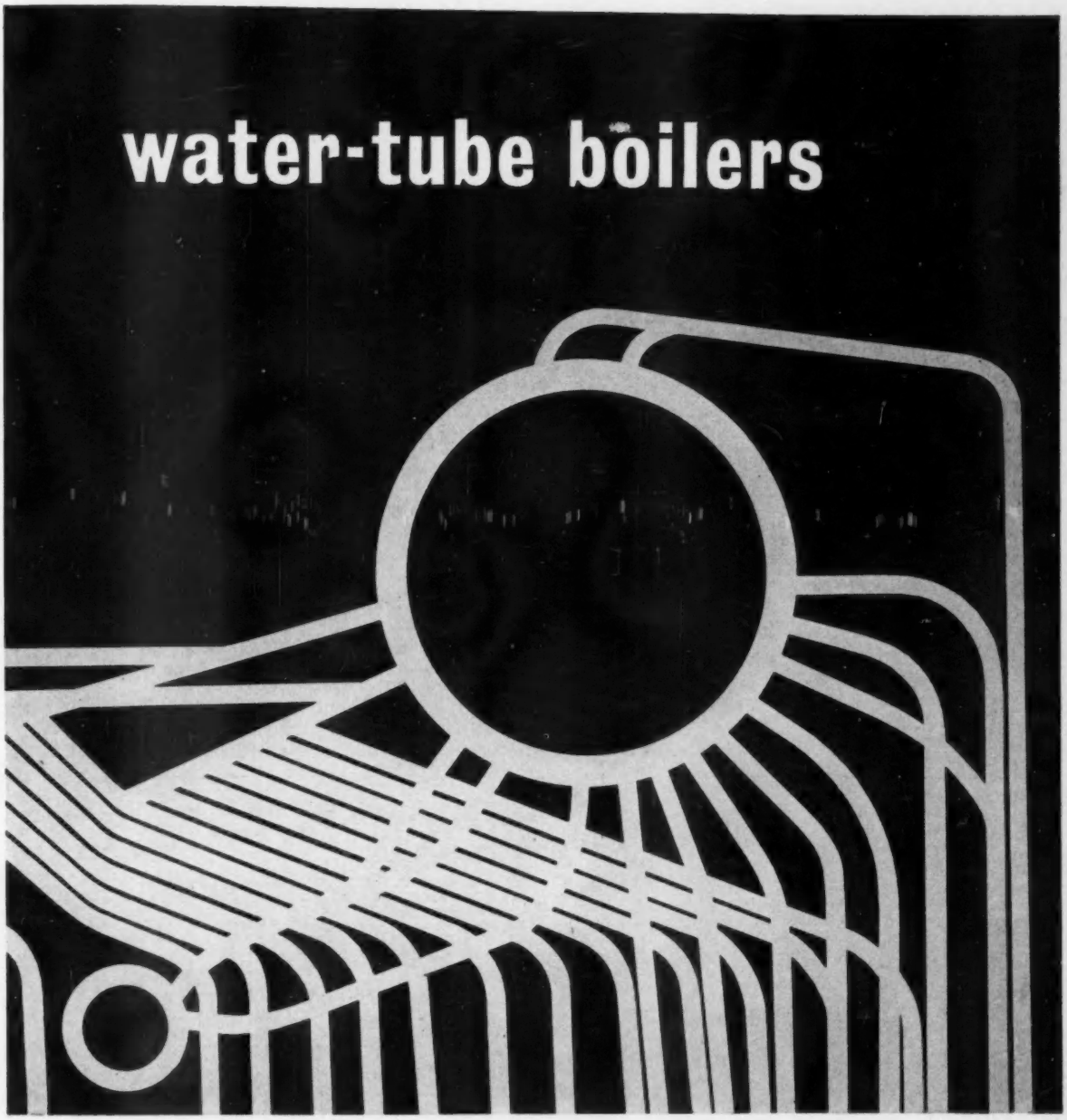

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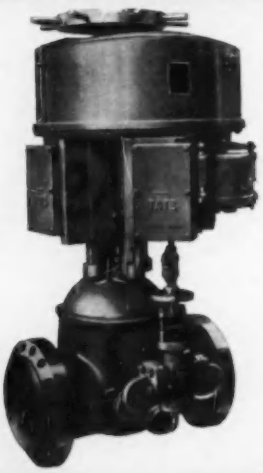

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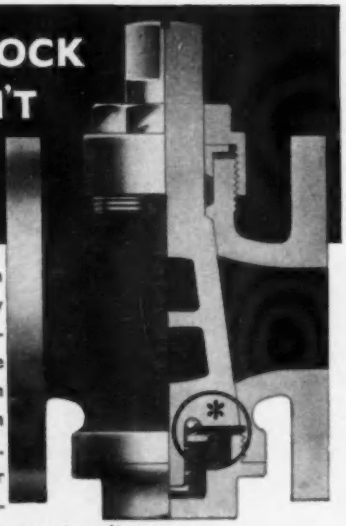

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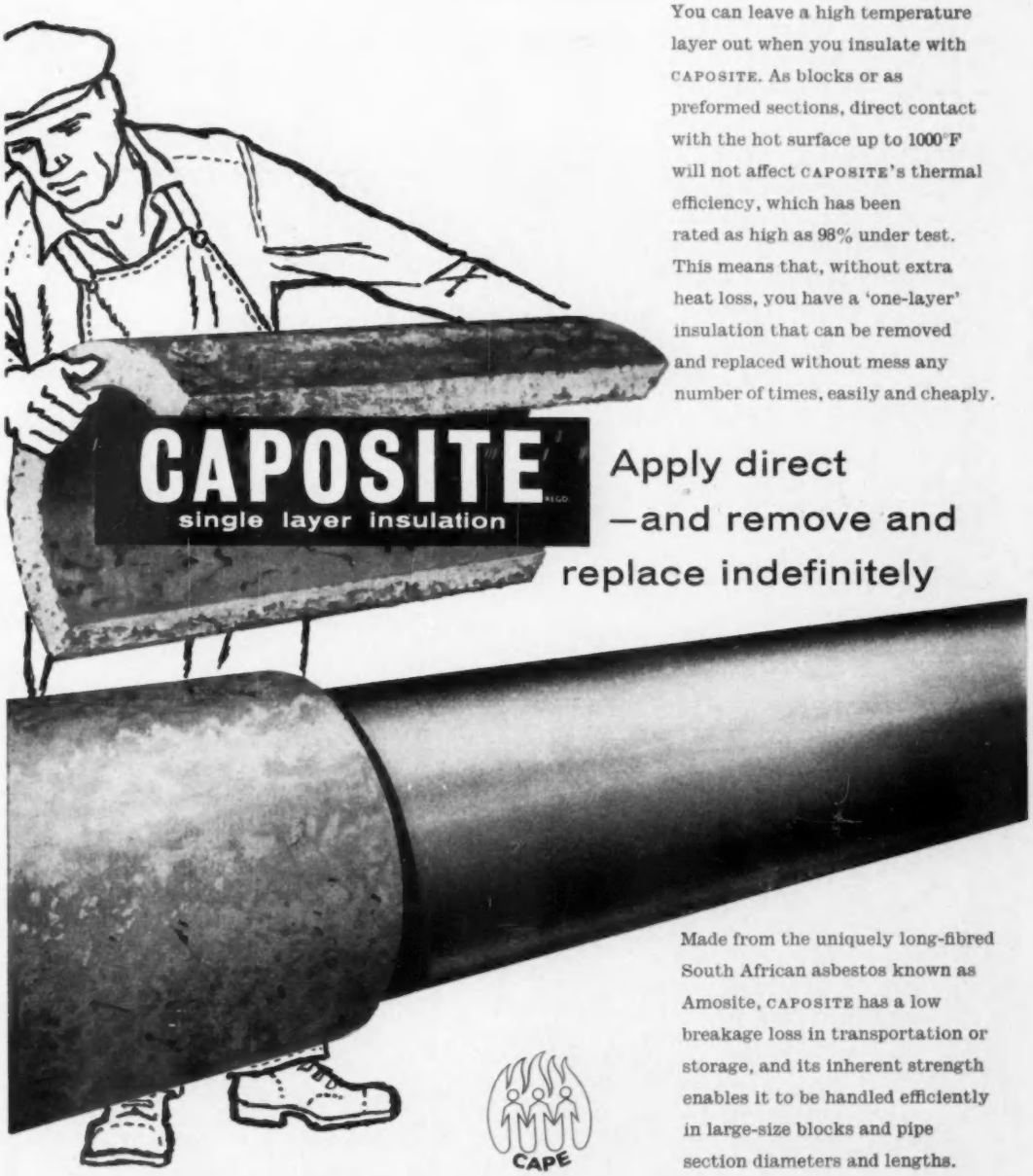

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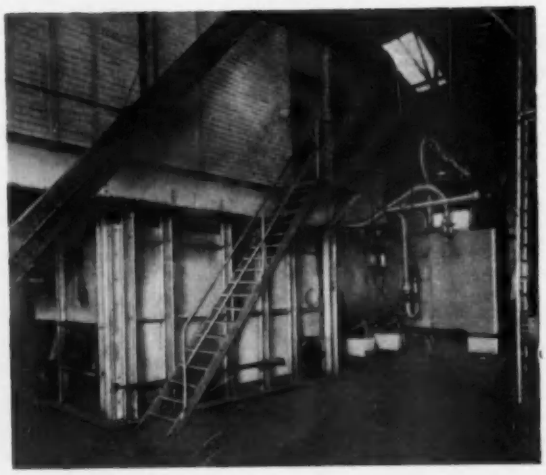

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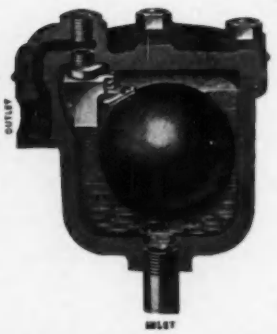

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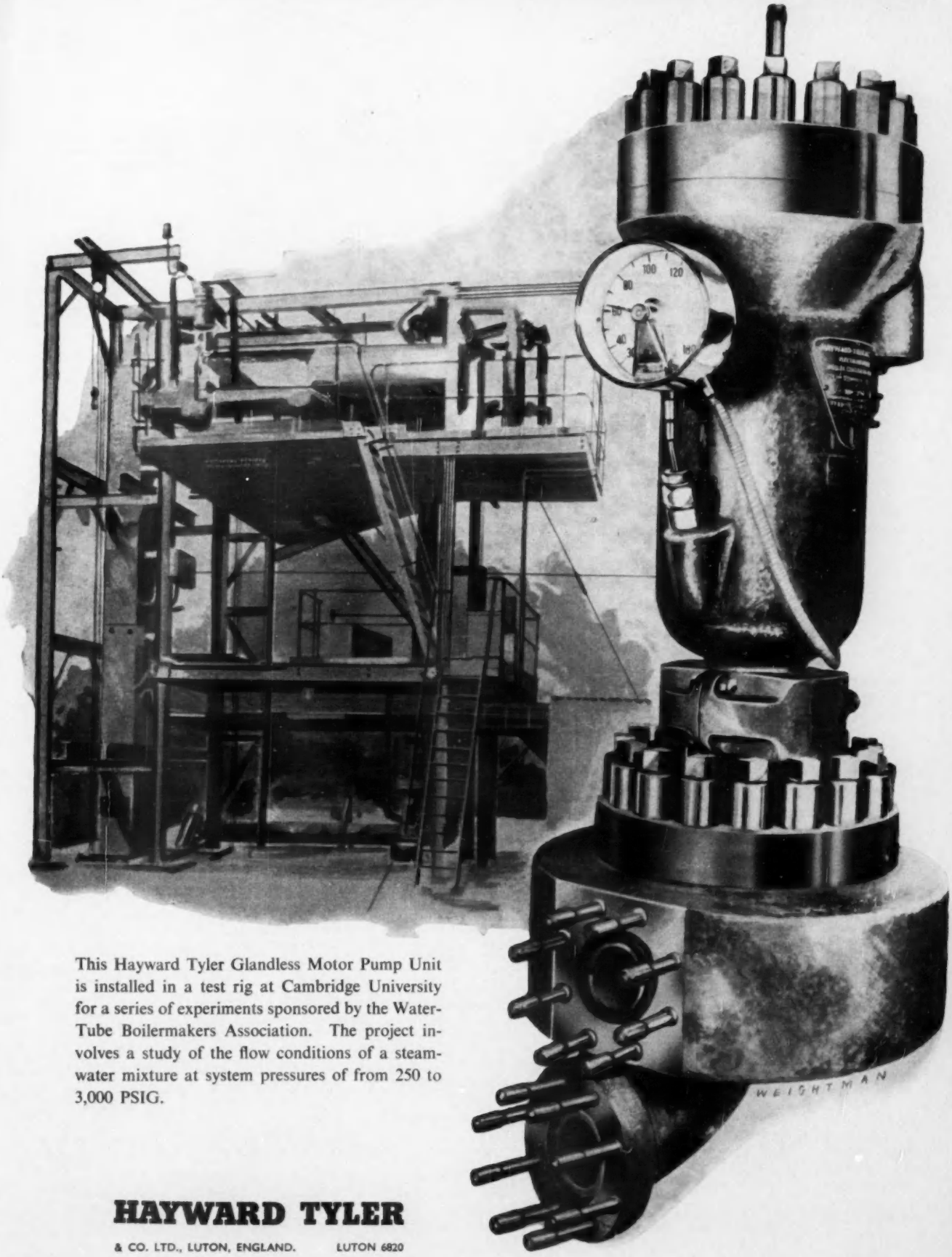

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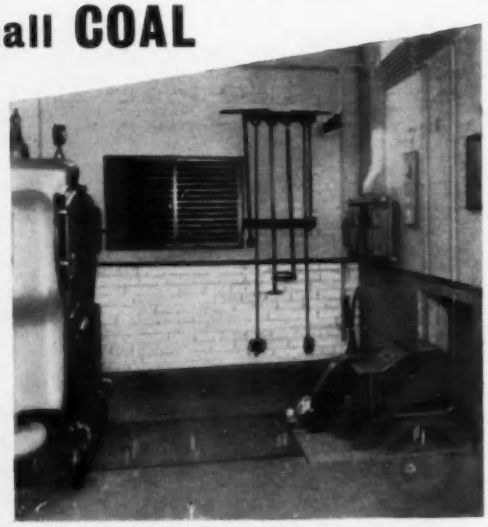

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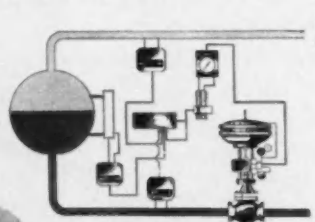
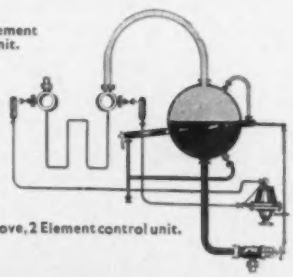


Left, 3 Element control unit.



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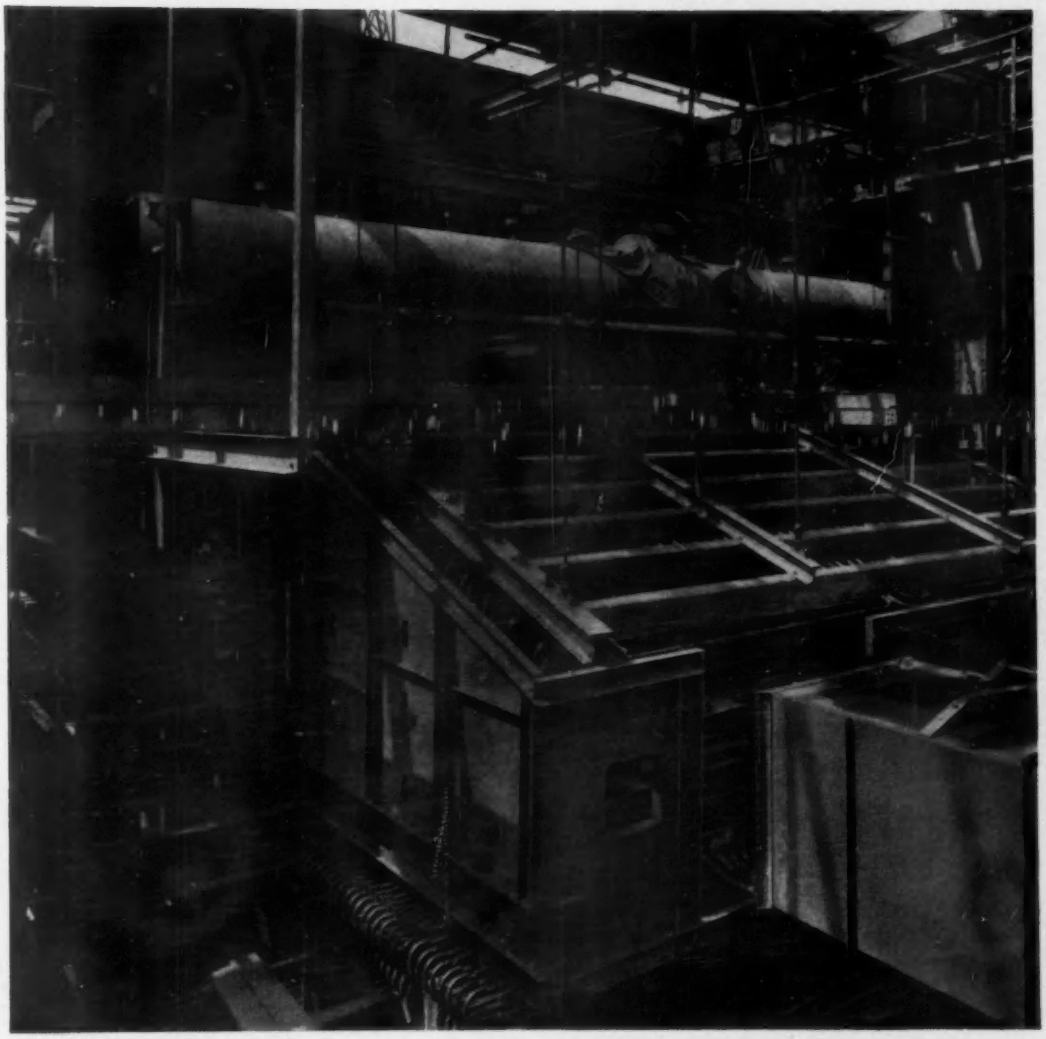

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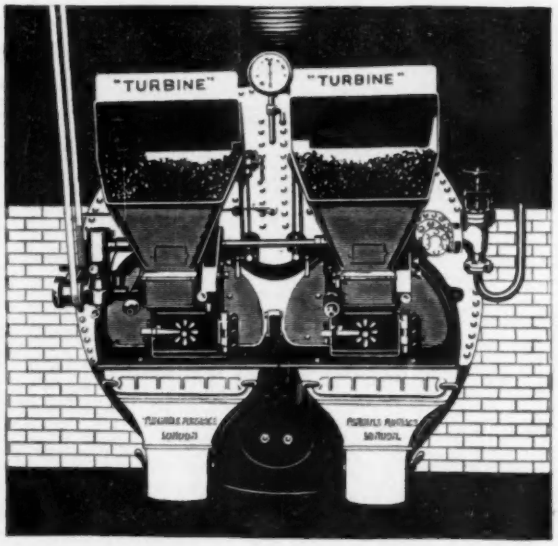

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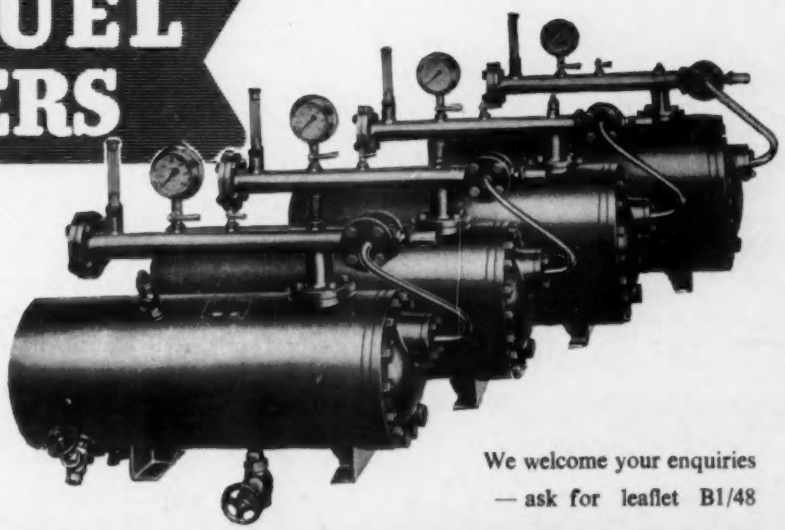

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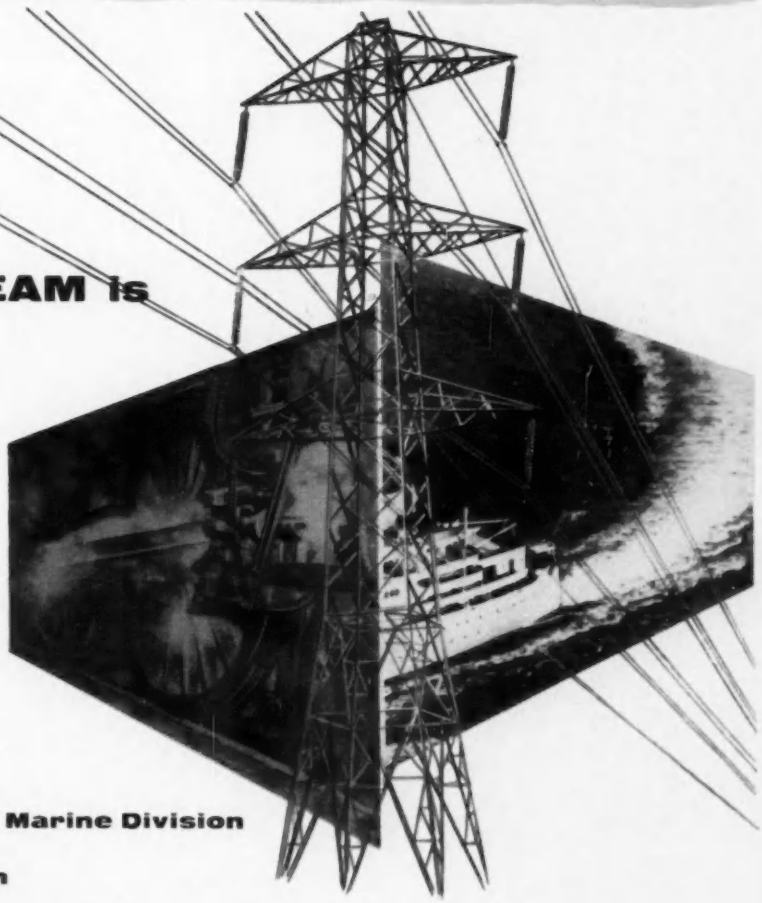

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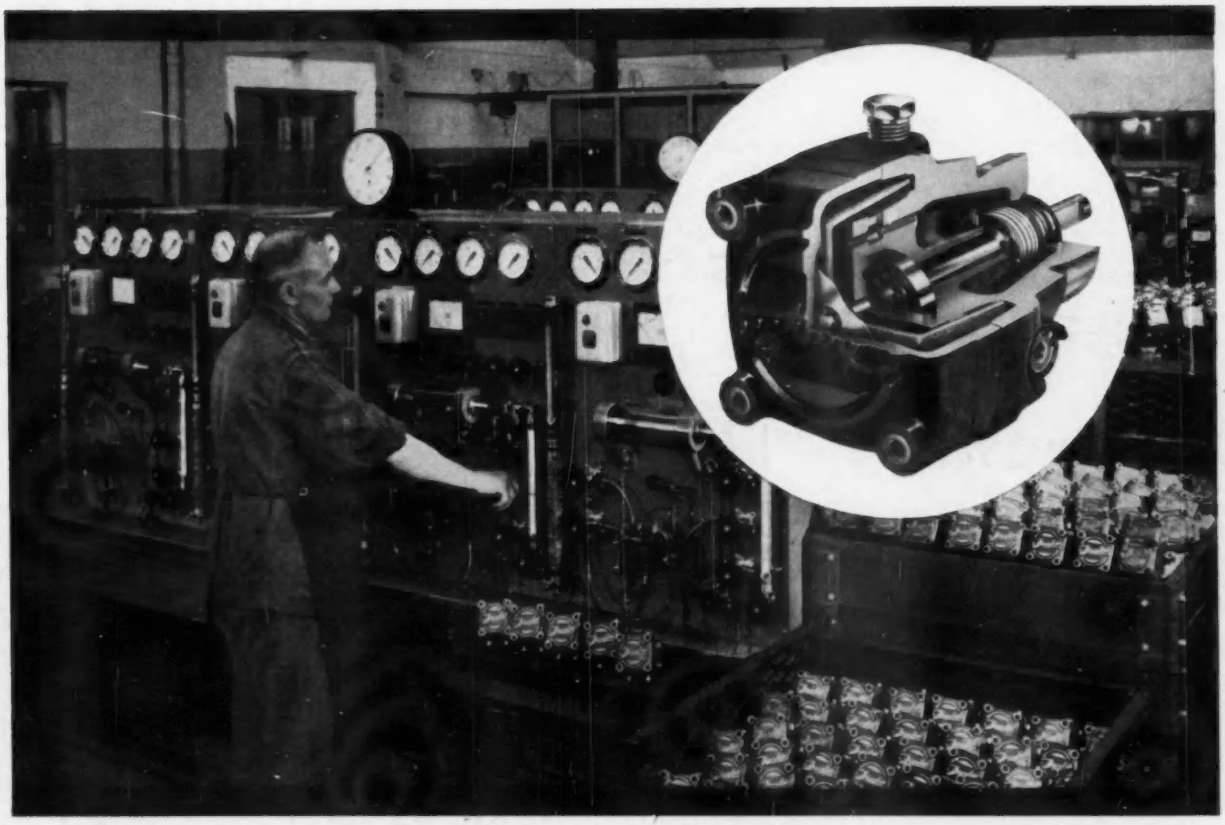

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